

STEEL PRODUCTS MANUAL

Cold Finished Alloy Steel Bars

Section 29

AMERICAN IRON AND STEEL INSTITUTE
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FOREWORD

Herewith is presented Section 29 of the Steel Products Manual covering Cold Finished Alloy Steel Bars.

It is the purpose of the Steel Products Manual to make available to purchasers, producers, consumers and all others interested, information covering the major steel products. Each section deals with tolerances, methods of inspection, sampling and chemical analysis, definitions of technological terms and other related subjects, which have developed in the manufacture and use of iron and steel. A list of the sections of the Steel Products Manual which have been published appears on the inside back cover. These sections will be revised from time to time and other sections may be issued.

It is the hope of American Iron and Steel Institute that this Manual will be of service both to producers and users of steel products and to the general public. Comments, suggestions and criticism from any source will be welcome.

WALTER S. TOWER

President

STEEL PRODUCTS MANUAL

Section 29

Cold Finished Alloy Steel Bars

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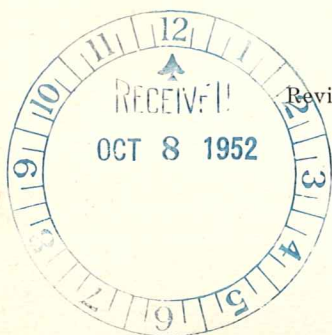
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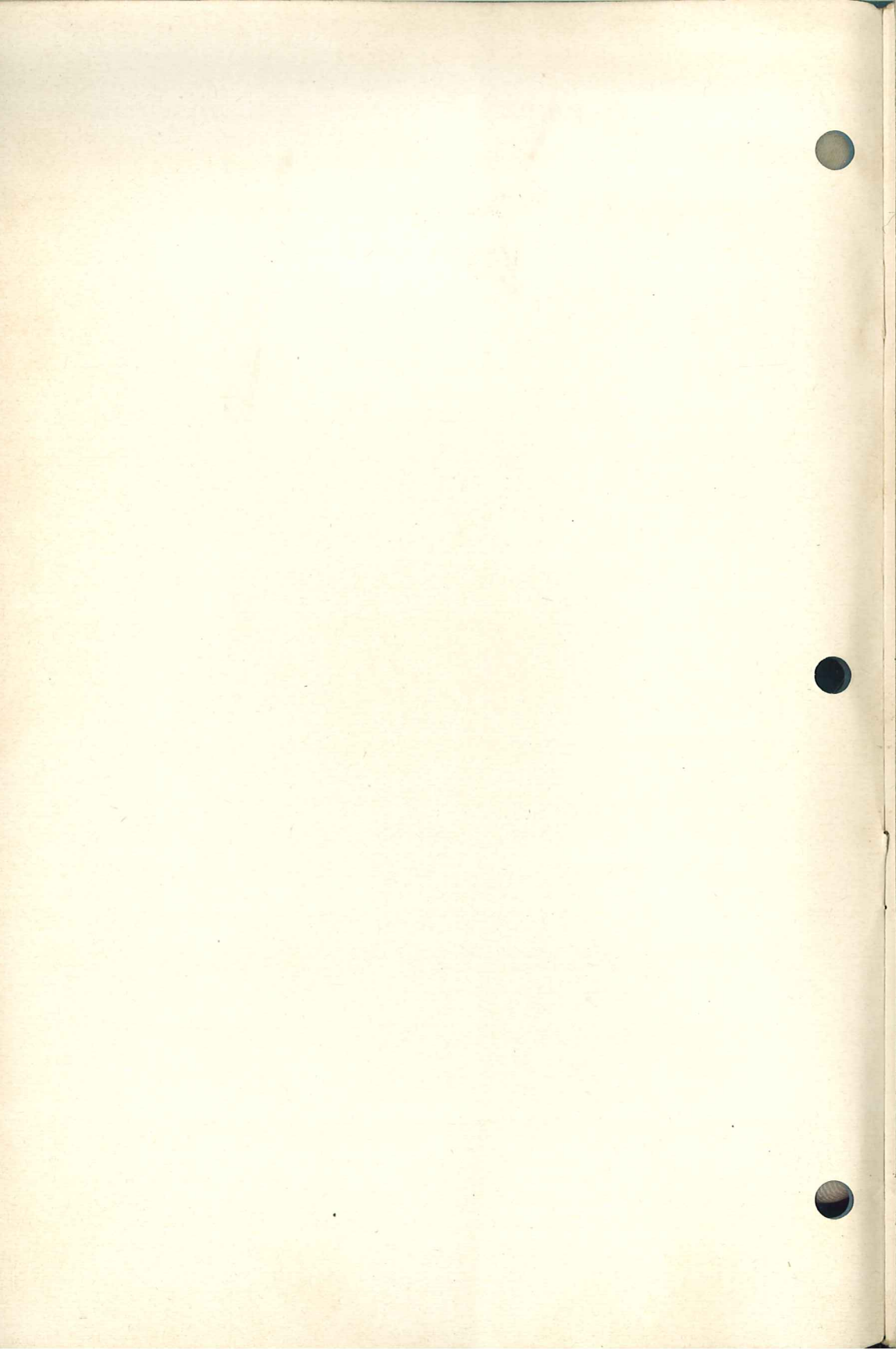
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Part I

METHODS OF MANUFACTURE

COLD FINISHED ALLOY STEEL BARS

Part I

METHODS OF MANUFACTURE

Introduction

Cold finished alloy steel bars are produced from hot rolled steel by several cold finishing processes, for the purpose of improving surface finish, dimensional accuracy, alignment, or machinability; also, in the case of cold drawn or cold rolled bars, to increase the yield strength and tensile strength. Cold finishing processes and surface improvement processes used singly or in combination include cold drawing, cold rolling, turning, grinding, polishing and straightening.

The cold finished bar industry began with a cold rolling process invented by Bernard Lauth at Pittsburgh about 1859. In that process hot rolled wrought iron bars were cold reduced to finish size by repeated passes between driven rolls. The new process, in addition to producing accurate size and bright, smooth surface, also imparted greater rigidity to the bar.

Some years later, as steel began to take the place of wrought iron in many of its uses, the cold rolling method was found to be equally suitable for steel shafting, and that process was used for fifty years or more. The term cold rolled steel, accordingly, came into general use and has persisted to describe, somewhat loosely, bar sections processed by cold drawing or other methods of cold finishing.

Toward the end of the nineteenth century the use of wire-drawing methods was gradually extended to larger sizes more properly classed as bars, and today cold drawing is the process by which most of the cold finished bar products are made. It was found that the cold work in the drawing process produced practically the same mechanical properties in the metal as were produced in cold rolling, such as increased tensile strength and yield strength, along with accuracy of size and a smooth, bright finish, and the two process names became synonymous.

For many years cold rolled or cold drawn bars were used principally as power transmission shafting in textile mills and factories and as shafts in farm implements and other machinery. The growth of the automotive and other machine manufacturing industries brought forth increasing demands for interchangeable machine parts and broadened the use for this product.

The development of turning, grinding and polishing processes was a major advancement in the production of cold finished bars from hot rolled steel. These processes provide close control of finished size and a high degree of surface finish without significantly changing the mechanical properties of the hot rolled steel. These processes are used in the production of cold finished bars for shafting and a wide range of other end uses.

COLD DRAWING

Bars of practically any cross section that is uniform throughout their length may be cold drawn. The process consists essentially in pulling a hot rolled, cleaned and coated bar or rod through the hole of a die of similar shape but smaller dimensions. One method of preparing the bar for starting it through the die is to taper or "point" one end. Another method is to push or extrude the bar through the die far enough for the grips to take hold.

Before cold drawing, the bars are cleaned by pickling or other descaling methods. They are then washed in clear water and dipped in a hot lime solution which retards rusting and aids in carrying the lubricant into the die.

Depending primarily on their cross-sectional areas, bars are commonly cold drawn by one of two different types of machine. For bars larger than about $\frac{1}{2}$ in. diameter, a draw bench is commonly used. The bench consists of a heavy frame up to 40 feet or more in length, on an end of which is mounted a die head containing one or more dies. The mechanism for pulling the bars through the dies consists of a heavy power-driven endless chain to which is attached a carriage with grips to grasp the bar or bars.

Sizes produced by the hot mills in coils are generally cold

drawn on a block which consists of a power-driven cylindrical drum on which the product is coiled as it comes through the die. The drawn product can be furnished in coils or as straightened-and-cut lengths.

Dies for cold drawing are made of very hard carbon tool steel, special alloy tool steel, or more recently of a material called cemented carbide which is nearly as hard as diamond. The dies are so designed that the bar will be gradually reduced in section as it is drawn through the hole, and the smallest cross section of the hole controls the finished size of the bar. The taper in the die exerts a compressive and elongating action on the bar, and permits gradual reduction in size. A reduction or "draft" of $\frac{1}{64}$ in. to $\frac{1}{8}$ in. is commonly used depending upon the composition, shape and size of the material to be drawn, and the properties desired in the finished bar.

General practice in cold drawing is to reduce to desired size in one pass through the die. Some shapes or grades of steel may require two or more passes and frequently intermediate annealing is necessary.

In the operation of cold drawing proper lubrication is of prime importance. In addition to the lime with which the bar is coated, heavy greases, oils, soaps or other lubricants are used.

Cold drawn bars are generally not straight as they come from the die because of stresses set up within them during the drawing operation. They are therefore straightened in machines designed to deflect the bar sufficiently to set up equalizing counter stresses and thus keep the bar straight. After straightening, bars are cut to desired lengths, commonly by shearing or by machine cutting.

Special Sections. Through developments in the art of cold drawing in recent years it has become possible to supply many irregular sections which formerly were machined from standard sections. This development has enabled more rapid production of interchangeable parts, with economies of metal and increased manufacturing flexibility.

Beginning with a few special sections, the industry is now called upon to consider hundreds of special sections annually.

The degree of accuracy required in the cold drawn section is an element of importance and often a deciding factor for its use. The tolerances within which any section can be drawn are dependent upon the size and nature of the cross section, the grade of steel specified, or the mechanical properties required. In many instances the bright finish combined with dimensional accuracy enables the stock to be used without additional machining.

The process employed in the production of special sections often departs from the usual method of one-pass drawing. Generally, special sections are processed by one of the following methods:

- (a) Cold drawing from a special hot rolled section.
- (b) Multiple drafting with intermediate anneals from a standard round, hexagon, square, flat or special hot rolled section.

Mechanical Properties. Marked changes in the mechanical properties of hot rolled bars are brought about by cold drawing or cold rolling. The most important of these are increases in tensile strength, yield strength*, hardness, torsional strength, resistance to wear, and a decrease in ductility.

The customary method of obtaining the yield strength (yield point*) on cold drawn, or cold drawn and subsequently heat treated bars, is to determine the value recorded at 0.005 inch per inch of gage length in extension under load with an appropriate measuring device. Other values, such as proportional limit, proof stress and elastic limit are not commonly required for cold drawn steel bars and only to a limited extent for cold drawn and subsequently heat treated bars.

Machinability. One of the best known characteristics of cold drawn steel bars is improved machinability, particularly in the lower carbon grades. In automatic screw machine work, the accuracy of size and section of cold finished bars as

* Cold drawn or cold rolled bar steel does not give the stress-strain characteristic that is commonly considered the yield point. The yield strength is commonly determined by methods given in A.S.T.M. Standard E 8.

compared to hot rolled bars tends to minimize collet troubles and the freedom from scale increases tool life.

The ratio of yield strength to tensile strength is an influencing factor on machinability. The high yield-tensile ratio resulting from cold drawing minimizes the plastic flow of metal during machining, permitting much of the tool energy to be utilized in shearing the chip.

TURNING AND POLISHING

In this process, straightened hot rolled round bars are reduced to the desired size by turning in a lathe or a special purpose turning machine to remove the rough surface metal, and are finished by buffing or polishing between steel burnishing rolls. The surface finish is smoother and brighter than that obtained by cold rolling or cold drawing, with equal accuracy in size. The mechanical properties of the finished bars are essentially the same as those of the bar steel used. Turned and polished rounds are relatively free from internal stresses as compared with cold drawn bars and are commonly preferred where distortion is objectionable in subsequent machining.

Bars of this finish are used mostly for shafting or similar uses which require a higher surface quality than is normal for cold rolled or cold drawn products. The turning operation generally removes decarburization, seams, slivers and other surface imperfections which sometimes occur in hot rolled bars.

Sizes made by turning and polishing commonly range from 1¼ in. diameter to 8 in. diameter.

TURNING, GRINDING AND POLISHING

In this process, straightened hot rolled round bars are turned in a lathe or special purpose turning machine and finished by grinding and buffing or polishing between steel burnishing rolls.

The turning and grinding operations generally remove decarburization, seams, slivers and other surface imperfections which sometimes occur in hot rolled bars. The turned

ground and polished rounds are relatively free from internal stresses as compared with cold drawn bars, and are commonly preferred where distortion is objectionable in subsequent machining and where a high degree of size accuracy and smoothness of surface are desired. The mechanical properties of the hot rolled bar are essentially unchanged by these processes.

Sizes made by turning, grinding and polishing commonly range from approximately $1\frac{1}{4}$ to 8 in. diameter.

COLD DRAWING, GRINDING AND POLISHING

For producing a high quality of surface on bars of small diameters, the bars are first cold drawn, then centerless ground followed by a final polish. Sizes of rounds commonly ground and polished from cold drawn bars range up to $1\frac{5}{16}$ in. diameter. The mechanical properties are similar to those of cold drawn bars of the same grade.

Several descriptive terms are used for special finishes, such as PISTON ROD, JEWELERS' ROD, NEEDLE BAR STOCK, and others.

COLD ROLLING

This process is seldom used except for flat bars of dimensions that cannot conveniently be cold drawn. Hot rolled bars of any suitable cross section are cleaned of scale by pickling or other means, and then passed repeatedly through a set of driven rolls which reduce the section with each pass until the piece is worked to the desired size and surface finish. Wide, thin, flat sections sometimes have the edges subsequently milled square.

The cold work of this process imparts to the bars a smooth surface finish, closeness to size, and a marked increase in the tensile strength, yield strength and hardness, with a corresponding decrease in ductility.

Part II
MANUFACTURING PRACTICES

Part II

MANUFACTURING PRACTICES

Introduction

This section of the Steel Products Manual relates only to constructional cold finished alloy steel bars and does not include tool steels or stainless steel.

It is characteristic of alloy steels in general that they require more than ordinary care throughout their manufacture. They are more sensitive to thermal and mechanical operations, the control of which is complicated by the varying effects of different chemical combinations. To secure the most satisfactory results, purchasers normally consult with the steel producer regarding the working, machining, heat treating or other operations to be employed in fabricating the steel ordered, the mechanical properties to be obtained, and the conditions of service for which the finished articles are intended. Particular attention should be given to informing the producer regarding the details of the first operation to which the steel will be subjected and subsequent operations where significant.

Alloy steels can be furnished suitable for cold heading, cold upsetting, cold forging, heat treating or carburizing.

The subject of grades is discussed fully in Part IV covering Standard Steels. Tables are shown of standard grades based on chemical composition. A system of prefix letters and numerals, given in the tables and explained in the text, provides a designation for each of the standard steels.

DESCRIPTIONS

Alloy Steel. By common custom steel is considered to be alloy steel when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: manganese, 1.65 per cent; silicon, 0.60 per cent; copper, 0.60 per cent; or in which a definite range or a

definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, boron, chromium up to 3.99 per cent, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying element added to obtain a desired alloying effect.

Grain Size. Austenitic grain size is specified as coarse or fine, determined in accordance with ASTM Specification E-19 of latest issue. The steel is designated as coarse grain when the grain structure falls within the numbers 1 to 5, inclusive, of the aforementioned specification, and fine grain when the grain structure falls within the numbers 5 to 8, inclusive.

Some variation in grain size is to be expected both inside and outside the specified range. In the preparation of a grain size sample for examination, considerable variation is to be expected as all grains will not be sectioned through their maximum diameters. Because of this variation, it is felt that the overlapping of one grain size number (5) between coarse and fine grain steels presents no problem since it is practically impossible to obtain a heat of steel which would be uniformly number five (5) grain size.

In the interest of determining grain size as accurately as possible for the ultimate application of a heat of steel, the following facts should be recognized and applied.

Before carburizing for grain size determination, it is advisable to normalize all specimens at 1700 F minimum in order to obtain a favorable comparison with the carburized grain size as determined by the purchaser on normalized or annealed parts.

It is also recommended that all cold drawn, normalized or otherwise heat treated surfaces of a specimen, forming part of the area under examination for grain size, be removed by suitable means prior to carburizing in order to eliminate the influence of scale or decarburization in the formation of the grain outline.

When difficulties are encountered in evaluating grain size by the carburizing test described above, it is suggested that

the fracture grain size after quenching from SAE recommended temperatures be used, as follows:

Fine grain steels are those which, after quenching and fracturing in sections not exceeding $\frac{3}{4}$ inch in maximum dimensions, show a crystalline structure of 5 or finer.

Carburizing steels are rated from the fracture of the carburized case.

The higher carbon deep hardening types are normally quenched from temperatures only slightly in excess of their upper critical (Ac3) temperature. The fracture grain size of these steels should be rated in a zone containing at least 50 per cent martensite.

It is not practicable to produce all sizes of steel in all types within specific grain size ranges and meet magnetic particle inspection requirements. Therefore, when magnetic particle inspection requirements are specified, grain size limits, if desired, are negotiated between purchaser and producer.

Hardenability can be specified for any of the steels identified as H-steels, the standard limits for which are shown in Part V. These limits are derived from experience with the standard end-quench test, the dimensions and testing procedure for which are set forth in SAE-AISI "Contributions to the Metallurgy of Steel—No. 11" of latest issue.

SIZE

Cold finished alloy steel bars comprise a variety of cross sections and sizes for which definitions and other conditions as commonly employed in the industry are stated herein. This product is normally furnished in straight lengths, but can be supplied in coils dependent upon size, section and mill equipment.

The nominal dimensions of cold finished alloy steel bars are designated in inches and fractions or decimal parts thereof. Variations in the specified cold finished dimensions are listed for the respective sections and sizes in standard practice Tables 1 and 2.

The size ranges of sections commonly listed by producers as cold finished alloy steel bars include the following:

Rounds, up to $7\frac{3}{4}$ in. inclusive.

Squares, up to 4 in. inclusive.

Hexagons, up to $3\frac{1}{8}$ in. inclusive.

Flats, $\frac{1}{4}$ in. and over in specified thickness, and up to 12 in. in specified width.

SPECIAL BAR SECTIONS

All producers do not make all sections or all sizes within the limits shown herein. Sizes and sections outside those limits, and special bar sections are commonly negotiated between purchaser and producer.

GRADES

Grades of cold finished alloy steel bars are commonly specified to chemical compositions with standard steel designations.

The subject of grades is discussed in Part IV. Tables are shown of standard grades based on chemical compositions. A system of prefix letters and numerals, given in the tables and explained in the text, provides a designation for each of the standard steels.

LENGTHS

Cold finished bars are commonly specified in feet and inches and in either random lengths or specific lengths. The smaller sizes are sometimes specified in coils. Shearing, sawing and lathe cutting are methods used in cutting to length. In shear cutting, some distortion of the bar ends occurs but the condition is commonly controlled to the extent that it does not interfere with insertion of the bars in the ordinary collet opening of automatic screw machines. This distortion does not occur in saw or lathe cutting and one of those methods is commonly specified for shafting or other applications where true section at the end of the bar and definite tolerance over the full length of the bar are required.

The following cold drawn sections and sizes in random or specific lengths are commonly produced with shear cut ends:

Rounds, hexagons and squares — 2 in. or smaller;
Flats — to 1 in. incl. in thickness, and not more than
6 in. wide; to 3/4 in. incl. in thickness, and
over 6 in. wide.

Random Lengths. A 24-inch length range is commonly considered necessary in random length cutting of cold finished bars 5 feet to 24 feet inclusive in length.

Specific Lengths. Cold finished bars are subject to a variable deviation in length due to variations in hardness resulting from differences in chemical composition, processing methods and thermal treatments. When the deviation from specified length is required to meet uniformly close limits, the length tolerance is commonly negotiated between the purchaser and the producer.

Specific lengths made up of multiple length units customarily include the amount required for loss in parting the desired number of units.

Coils. The following sections and sizes are sometimes specified in coils:

Rounds, hexagons and squares — 5/8 in. and smaller.
Flats — to 9/16 x 5/8 in. or other sections having
cross-sectional areas not more than 0.30 square
inch.

STRAIGHTNESS

Cold finished alloy steel bars are customarily produced within reasonable limits of true straightness and suitable for the majority of industrial uses such as, for example, the degree of straightness required for satisfactory operation in an automatic screw machine. For applications requiring uniformly close straightness within definite tolerances, the limits for maximum deviation from true straightness and details of the methods to be used in checking straightness are commonly negotiated between purchaser and producer.

TOLERANCES

The variations for cold finished alloy steel bars of various finishes are shown in Tables 1 and 2.

Table 1A
Tolerances for Cold Finished Alloy Steel Bars

Size, in inches	Maximum of Carbon Range 0.28 per cent or less	Maximum of Carbon Range Over 0.28 to 0.55 per cent incl. or All Carbons Annealed	Maximum of Carbon Range Over 0.55 per cent or All Carbons Heat Treated or Stress Relieved
All tolerances are in inch and are minus			
ROUNDS — COLD DRAWN OR TURNED AND POLISHED			
To 1 incl.	0.003	0.005	0.007
Over 1 to 2 incl.	0.004	0.006	0.009
Over 2 to 4 incl.	0.005	0.007	0.011
Over 4 to 6 incl.	0.006	0.008	0.013
Over 6 to 7 $\frac{1}{4}$	0.007	0.010	0.017
HEXAGONS — COLD DRAWN			
To 5/16 incl.	0.003	0.005	0.007
Over 5/16 to 1 incl.	0.004	0.006	0.009
Over 1 to 2 $\frac{1}{2}$ incl.	0.005	0.007	0.011
Over 2 $\frac{1}{2}$ to 3 $\frac{1}{8}$ incl.	0.006	0.008	0.013
SQUARES — COLD DRAWN			
To 5/16 incl.	0.004	0.006	0.009
Over 5/16 to 1 incl.	0.005	0.007	0.011
Over 1 to 2 $\frac{1}{2}$ incl.	0.006	0.008	0.013
Over 2 $\frac{1}{2}$ to 4	0.007	0.010	0.017
FLATS — COLD FINISHED			
Width, in inches			
To $\frac{3}{4}$ incl.	0.004	0.006	0.009
Over $\frac{3}{4}$ to 1 $\frac{1}{2}$ incl.	0.005	0.007	0.011
Over 1 $\frac{1}{2}$ to 3 incl.	0.006	0.008	0.013
Over 3 to 4 incl.	0.007	0.010	0.017
Over 4 to 6 incl.	0.009	0.012	0.021
Over 6	0.014	—	—

The above tolerances provide for undersize variations only.
The tolerances for flats apply to thickness as well as width.

Table 2
**Cold Drawn, Ground and Polished or
Turned, Ground and Polished Rounds**

Diameters	Variations From Size, in.	
	Plus	Minus
Less than 2 $\frac{1}{2}$ "	0.000"	0.002"
2 $\frac{1}{2}$ " and larger	0.000"	0.003"

Restricted Tolerances. Cold finished bars are sometimes furnished to size tolerances more restrictive than shown in Tables 1 and 2. Certain close accuracies can be produced only by grinding to final finish. Hexagons, squares and flats are not adaptable to grinding and therefore do not run to as high a degree of precision as is available in rounds.

The production of bars to closer than standard tolerances is commonly negotiated between purchaser and producer

and the extent of restriction is influenced by the section, size, grade and cold finishing process.

CUTTING

The following cold drawn sections and sizes in random or specified lengths are commonly furnished with shear cut ends:

Rounds, hexagons and squares—2 in. or smaller.

Flats—up to 1 in. incl. in thickness, and not more than 6 in. wide;
up to $\frac{3}{4}$ in. incl. in thickness, and over 6 in. wide.

Chamfering. When specified, one or both ends of rounds, squares or hexagons are chamfered. Shear cutting is commonly used on cold finished bars for most automatic screw machine purposes without chamfering.

HEAT TREATMENTS

Annealing indicates a single thermal treatment, intended to place the steel in a suitable condition for fabrication. The steel is heated to a temperature in or near the critical temperature range, and is cooled at a predetermined rate or cycle. The temperature and cooling rate or cycle are dependent upon the properties desired by the purchaser. This treatment may be necessary to facilitate cold drawing, turning or grinding operations. Alloy steels over 0.38 per cent maximum carbon, are generally annealed prior to cold drawing. For best results in machining it is sometimes advisable to specify annealing for lower carbon contents.

Box or Pipe Annealing consists in enclosing the steel in a suitable metal container during the annealing process to protect it from objectionable oxidation.

Normalizing consists in heating the steel to above its critical temperature range and cooling in air.

Quenching and Tempering consists in heating the steel to the proper temperature, holding at that temperature for a sufficient time to effect the desired change in crystalline structure, and quenching in a suitable medium — water, oil, or air — depending upon the chemical composition and cross section. After quenching, the steel is reheated to a predetermined temperature below the critical range and then cooled under suitable conditions.

It is sometimes necessary to use processes that involve two or more combination heating and cooling operations such as, quenching and tempering, normalizing and tempering, and normalizing, quenching and tempering.

Spheroidize Annealing consists in a prolonged heating of steel at a temperature at or near the lower critical point, followed by slow cooling to produce a globular condition of the carbide. This treatment produces a structure that is often desirable for machining or cold-forming operations, or for the effect it will have on subsequent heat treatments.

Stress Relieving consists in heating the steel to a low temperature after cold finishing, to minimize distortion in subsequent machining or to restore elastic properties. This treatment is generally accompanied by a discoloration of the surface.

PROTECTIVE COATINGS

Cold finished bars are commonly given a surface coating of oil or other materials recognized as rust inhibitors as a protection against rust during shipment and subsequent temporary storage. In extended storage or when stored in contaminated atmospheres, further precautionary measures are sometimes necessary to prevent rusting.

MECHANICAL PROPERTIES AND TESTS

It is not practicable to set up definite limitations for tensile or hardness values for alloy steels in the cold finished condition. In the annealed and cold finished condition, maximum hardness or maximum ultimate tensile strength is sometimes specified. For steel in the normalized condition, either maximum hardness or maximum ultimate tensile strength or minimum hardness or minimum ultimate tensile strength are sometimes specified. If the steel is normalized and tempered before cold finishing, either maximum and minimum hardness or maximum and minimum tensile values are commonly specified provided the range, which varies with the ultimate tensile strength level, is equivalent to a Brinell indentation diameter range of at least four-tenths of a millimeter (e.g. 4.0 to 4.4) at any specified location. If the steel is quenched and tempered before cold finishing, either maximum and minimum hardness or maximum and minimum tensile strength values are sometimes

specified, provided the range, which varies with the ultimate tensile strength level, is equivalent to a Brinell indentation diameter of at least three-tenths of a millimeter (e.g. 3.6 to 3.9) at any specified location.

When both hardness and tensile values are specified at the same position the limits should be consistent with each other. When the Brinell limits are specified as surface values the tensile test results, which are of necessity obtained below the surface, and the surface hardness results, in many cases, will not be consistent because they vary according to the size of bar and the hardenability of the steel involved. For this reason the purchaser should recognize inconsistencies between the two and specify limits accordingly. In either case it is essential that the position at which Brinell hardness values are taken be clearly stated by the purchaser.

Generally, the yield, elongation and reduction of area are specified as minimums for steel in the quenched and tempered or normalized and tempered conditions, and they should be consistent with the ultimate tensile strength or Brinell hardness.

Unless otherwise agreed upon, the longitudinal axis of tension test specimens is located at the center of bars up to 1½ in. and midway between the surface and center for bars 1½ in. and larger.

MAGNETIC TESTING

Magnetic testing is a nondestructive method for detecting objectionable surface defects which may not be readily discernible by customary visual inspection practices. This method should not be confused with magnetic particle inspection described on pages 26 and 27 in this Section 29.

In magnetic testing, each individual bar is passed through the magnetic field of the machine, and defects at the surface, such as seams, cracks, laps or other discontinuities, are detected and the indications reflected by suitable magnetic measurements. The detection of the magnitude of the surface defects depends upon the method of cold finishing, grade of steel, prior thermal treatment, bar size, section, etc. When required, magnetic testing to maximum limits for depth of defects is negotiated between the purchaser and producer.

INSPECTION

When purchaser's specifications stipulate that inspection and tests (except check analyses) for acceptance of the steel be made prior to shipment from the mill, the producer affords the purchaser's inspector all reasonable facilities to determine that the steel is being furnished in accordance with the specification. Cold finished alloy steel bars subject to purchaser's inspection and sampling are customarily inspected and sampled in conjunction with the producer's inspection and sampling operations. Any required separate inspection operation involving additional handling of steel is commonly negotiated between purchaser and producer.

In the case of unsatisfactory results on check analyses, the results should be reported promptly to the producer. Samples are commonly preserved at least two weeks, or submitted to the producer.

LIMITATIONS OF INSPECTION, TESTING AND CERTIFICATION

There are a number of intrinsic features of steelmaking and finishing processes that affect the properties or conditions of the finished products, and those effects cannot always be precisely known. Therefore, as a rule it is impracticable to give unconditional assurance of complete compliance with prescribed requirements. That fact is manifest to those having a technical knowledge of the subject, and to those skilled in the art of steel manufacture, and is recognized in applying a factor of safety. For example, the phenomenon of segregation causes variations in chemical composition, mechanical test results and soundness from ingot to ingot, and in different parts of each ingot. Variations in manufacturing practice such as control of temperatures, which cannot always be regulated with exactness, sometimes cause variations in mechanical properties in different parts of a heat or lot of steel.

Because of those and other conditions which are present in steel mill operations, it is not thought possible in the present state thereof to point out any reasonable or practical methods of inspection that will ensure the detection and rejection of every piece of steel in a shipment that varies slightly from the specified contract requirements with regard to dimensional tolerances, chemical composition, mechanical properties, surface and internal conditions.

Part III

QUALITY REQUIREMENTS

Part III

QUALITY REQUIREMENTS

Introduction

Steel quality as the term relates to cold finished alloy steel bars is indicative of many conditions, such as: the degree of internal soundness, relative uniformity of chemical composition or relative freedom from injurious surface imperfections. Steel quality also relates to the general suitability of the steel involved to make the desired part.

SPECIAL QUALITIES AND REQUIREMENTS

The special qualities and special requirements of cold finished alloy steel bars, which are described below, have characteristic properties adapted to the particular conditions encountered in the fabrication or use for which they are intended.

The production of these qualities and requirements necessitates more rigid controls and closer supervision of mill practices than normally required for cold finished alloy steel bars. These special qualities and requirements entail one or more of the following requisites in their manufacture:

1. Careful selection of raw materials for melting which vary with each requirement;
2. More exacting steelmaking practices;
3. Selection of heats or portions of heats with consequent higher loss than normal;
4. Additional discard specified or required;
5. Special supervision and inspection;
6. More extensive testing.

The freedom and scope of application of steel for the several qualities and requirements shown below are of necessity progressively limited as the end use becomes more severe. The processing methods used to obtain these special qualities and requirements are generally left to the discretion of the producer because of the variations in practices among producers.

Aircraft Quality or Steel Subject to Magnetic Particle Inspection. This quality designation applies to steels for important or highly stressed parts of aircraft and for other similar or corresponding purposes; such steels are of extremely high quality requiring closely controlled, restrictive and special practices in their manufacture. In order to meet the stringent requirements for such applications, unusual manufacturing risks are encountered.

The production of this quality product necessitates rigid control and close supervision of mill practices together with constant inspection at all stages in the process of manufacturing, in which several requisites such as the following are involved:

- Careful selection of raw materials for melting,
- Exacting steelmaking practices,
- Additional discard,
- Selection of heats or portions of heats,
- Exacting heating and rolling practices,
- Magnetic particle inspection,
- Macroetch tests,
- Grain size tests,
- Mechanical and hardenability tests.

The magnetic particle method of inspection consists of suitably magnetizing the steel and applying a prepared magnetic powder which adheres to it along lines of flux leakage. On properly magnetized steel, flux leakage develops along surface or subsurface nonuniformities.

The test was developed for and is used primarily on fully machined or ground surfaces or finished parts. When the magnetic particle test is to be applied to bar stock, short length samples should be completely machined or ground as nearly as feasible to the cross section and surface condition corresponding to the machined finished part they are to represent.

This method of inspection varies with the degree of magnetization, the procedure of conducting the inspection, including such conditions as relative location of surfaces tested, method and sequence of magnetizing and applying the powder, amperage and the interpretation of indications.

It is not practicable to meet magnetic particle inspection requirements for steel when specific grain size limits are desired. This condition, as well as methods of conducting any special tests, methods of inspection and interpretation of results, are commonly negotiated between purchaser and producer.

Axle Shaft Quality. This quality designation applies to bars intended for the manufacture of power driven axle shafts of the automotive or truck type, which by their design or method of manufacture are not machined all over or have insufficient stock removed for the proper clean-up of normal surface defects, or where inspection standards impose restrictive surface requirements. To meet these requirements entails special rolling practices, special billet and bar conditioning, and selective inspection.

Bearing Quality. Bearing quality steels are usually limited to the AISI-SAE standard alloy carburizing grades or the high carbon-chromium series. These steels are subjected to restricted melting and special teeming, heating, rolling, cooling and conditioning practices to meet rigid quality requirements.

These requirements require thorough examinations for minute imperfections by one or more of the following methods:

1. Microscopic examination.
2. Macroetch testing.
3. Fracture testing.

Cold Heading Quality. This term applies to steel required for applications involving severe cold plastic deformation by such operations as upsetting, heading or forging. Bars are supplied from steel produced by closely controlled steel-making practices and are subject to mill testing and inspection designed to assure internal soundness, uniformity of chemical composition and freedom from injurious surface defects. Cold finished alloy steel bars are generally specified annealed or spheroidize annealed to effect proper hardness or microstructure for cold heading.

microscope at a magnification of 100 diameters. The samples for testing should be taken on a longitudinal plane midway between the center and surface of the product. The location, number of tests, and interpretation of test results are negotiated between purchaser and producer.

Special Hardenability Test. This test consists of using any hardenability or equivalent mechanical property test other than the standard one inch end quench test (recognized by the Society of Automotive Engineers and American Society for Testing Materials and described in Contributions to the Metallurgy of Steel No. 11 of latest issue). A minimum or maximum hardenability or mechanical property value commensurate with the chemical composition ordered can be specified. The details of testing are negotiated between purchaser and producer.

Part IV

CHEMICAL REQUIREMENTS

STANDARD STEELS

**CHEMICAL RANGES AND LIMITS
FOR
STEELS OTHER THAN STANDARD**

Part IV

Introduction

For years the variety of chemical compositions and quality requirements of steel specifications have been a matter of concern in the steel industry. Having in mind the potential benefits of simplification, comprehensive and impartial studies were directed towards determining which of the many grades being specified were the ones in most common demand; also the feasibility of combining specifications having like requirements. These studies showed that thousands of different combinations of chemical elements, many of which differed very slightly from each other, were being manufactured to meet the individual demands of purchasers.

The facts thus developed indicated that if efforts were concentrated upon fewer grades, deliveries could be expedited and service improved. Moreover, there would be better opportunity to achieve advances in technical and manufacturing practices as well as quality, and thus develop more fully the possibilities of application inherent in those grades.

STANDARD STEELS

These studies to provide a simplified list of steel compositions to serve the significant metallurgical and engineering needs of fabricators and users of steel products resulted in the chemical compositions shown in Table 3, which are called Standard Steels. These standard steels were selected on the basis of metallurgical and engineering judgment after consideration of many factors, including the advice and counsel of engineering and specification writing bodies and the needs of the armed services.

The general acceptance and use of standard steels since their inception in 1941 have demonstrated that those steels

have, in almost all cases, successfully replaced the many steels of specialized compositions previously used.

The list of standard steels will be altered from time to time to accommodate steels of proven merit and to provide for changes which may develop in the metallurgical and engineering requirements of industry.

The ranges and limits for the respective chemical elements shown in Table 3, based on the experience of many years, are the limits to which standard alloy steels are produced under normal manufacturing conditions. Steels ordered to hardenability requirements, identified as H-Steels as described in Table 6, Part V, are also standard steels.

SYSTEM OF IDENTIFICATION

A system of symbols is used to identify the grades of standard steels. Numbers are used to indicate grades of steel by chemical composition.

The prefix letter E is used to designate steels made by the electric furnace process. These are specified as open hearth steels when appropriate adjustments are made in chemical limits as covered by footnotes to Table 3 and are standard steels. When no prefix letter is shown, the grade is manufactured by the basic open hearth process. These are specified as basic electric furnace steels when the appropriate chemical limits are used as in footnotes to Table 3, and are then standard steels.

Numerical Designations of Grades. A four-numeral series designates alloy steels specified to chemical composition ranges. Five numerals are used to designate certain types of alloy steels.

The last two digits of the four-numeral series are intended to indicate the approximate middle of the carbon range, i.e., 20 represents a range of 0.18 to 0.23 per cent. It is necessary, however, to deviate from this rule and to interpolate numbers in the case of some carbon ranges; and for variations in manganese, sulphur, chromium, or other elements.

The first two digits of the four-numeral series for the various grades of alloy steel and their meaning are as follows:

Series Designation	Types
13xx	Manganese 1.75 per cent
23xx	Nickel 3.50 per cent
25xx	Nickel 5.00 per cent
31xx	Nickel 1.25 per cent—Chromium 0.65 or 0.80 per cent
33xx	Nickel 3.50 per cent—Chromium 1.55 per cent
40xx	Molybdenum 0.25 per cent
41xx	Chromium 0.95 per cent—Molybdenum 0.20 per cent
43xx	Nickel 1.80 per cent—Chromium 0.50 or 0.80 per cent— Molybdenum 0.25 per cent
46xx	Nickel 1.80 per cent—Molybdenum 0.25 per cent
48xx	Nickel 3.50 per cent—Molybdenum 0.25 per cent
50xx	Chromium 0.30 or 0.60 per cent
51xx	Chromium 0.80 per cent, 0.95 per cent or 1.05 per cent
5xxxx	Carbon 1.00 per cent—Chromium 0.50, 1.00 or 1.45 per cent
61xx	Chromium 0.80 or 0.95 per cent—Vanadium 0.10 per cent or 0.15 per cent min.
86xx	Nickel 0.55 per cent—Chromium 0.50 per cent—Molybdenum 0.20 per cent
87xx	Nickel 0.55 per cent—Chromium 0.50 per cent—Molybdenum 0.25 per cent
92xx	Manganese 0.85 per cent—Silicon 2.00 per cent
93xx	Nickel 3.25 per cent—Chromium 1.20 per cent—Molybdenum 0.12 per cent
94xx	Manganese 1.00 per cent—Nickel 0.45 per cent—Chromium 0.40 per cent—Molybdenum 0.12 per cent
97xx	Nickel 0.55 per cent—Chromium 0.17 per cent—Molybdenum 0.20 per cent
98xx	Nickel 1.00 per cent—Chromium 0.80 per cent—Molybdenum 0.25 per cent

Table 3A

STANDARD STEELS

Open Hearth and Electric Furnace Alloy Steels

Subject to Variations for Check Analysis (Table 5)

AISI Number	Chemical Composition Limits, per cent								Corre- spond- ing SAE Number
	C	Mn	P	S	Si	Ni	Cr	Mo	
1320	0.18/0.23	1.60/1.90	0.040	0.040	0.20/0.35	—	—	—	1320
1321	0.17/0.22	1.80/2.10	0.050	0.050	0.20/0.35	—	—	—	—
1330	0.28/0.33	1.60/1.90	0.040	0.040	0.20/0.35	—	—	—	1330
1335	0.33/0.38	1.60/1.90	0.040	0.040	0.20/0.35	—	—	—	1335
1340	0.38/0.43	1.60/1.90	0.040	0.040	0.20/0.35	—	—	—	1340
2317	0.15/0.20	0.40/0.60	0.040	0.040	0.20/0.35	3.25/3.75	—	—	2317
2330	0.28/0.33	0.60/0.80	0.040	0.040	0.20/0.35	3.25/3.75	—	—	2330
2335	0.33/0.38	0.60/0.80	0.040	0.040	0.20/0.35	3.25/3.75	—	—	—
2340	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	3.25/3.75	—	—	2340
2345	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	3.25/3.75	—	—	2345
E 2512	0.09/0.14	0.45/0.60*	0.025	0.025	0.20/0.35	4.75/5.25	—	—	2512
2515	0.12/0.17	0.40/0.60	0.040	0.040	0.20/0.35	4.75/5.25	—	—	2515
E 2517	0.15/0.20	0.45/0.60*	0.025	0.025	0.20/0.35	4.75/5.25	—	—	2517
3115	0.13/0.18	0.40/0.60	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75	—	3115
3120	0.17/0.22	0.60/0.80	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75	—	3120
3130	0.28/0.33	0.60/0.80	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75	—	3130
3135	0.33/0.38	0.60/0.80	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75	—	3135
3140	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	1.10/1.40	0.55/0.75	—	3140
3141	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	1.10/1.40	0.70/0.90	—	3141
3145	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	1.10/1.40	0.70/0.90	—	3145
3150	0.48/0.53	0.70/0.90	0.040	0.040	0.20/0.35	1.10/1.40	0.70/0.90	—	3150
E 3310	0.08/0.13	0.45/0.60*	0.025	0.025	0.20/0.35	3.25/3.75	1.40/1.75	—	3310
E 3316	0.14/0.19	0.45/0.60*	0.025	0.025	0.20/0.35	3.25/3.75	1.40/1.75	—	3316
4017	0.15/0.20	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4017
4023	0.20/0.25	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4023
4024	0.20/0.25	0.70/0.90	0.040	0.035/ 0.050	0.20/0.35	—	—	0.20/0.30	4024
4027	0.25/0.30	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4027
4028	0.25/0.30	0.70/0.90	0.040	0.035/ 0.050	0.20/0.35	—	—	0.20/0.30	4028
TS 4012	0.09/0.14	0.75/1.00	0.040	0.040	—	—	—	0.15/0.25	—
4032	0.30/0.35	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4032
4037	0.35/0.40	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4037
4042	0.40/0.45	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4042
4047	0.45/0.50	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4047
4053	0.50/0.56	0.75/1.00	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4053
4063	0.60/0.67	0.75/1.00	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4063
4068	0.63/0.70	0.75/1.00	0.040	0.040	0.20/0.35	—	—	0.20/0.30	4068
4130	0.28/0.33	0.40/0.60	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15/0.25	4130

(Continued)

Table 3A—(Continued)

AISI Number	Chemical Composition Limits, per cent								Corre- spond- ing SAE Number
	C	Mn	P	S	Si	Ni	Cr	Mo	
E 4132	0.30/0.35	0.40/0.60	0.025	0.025	0.20/0.35	—	0.80/1.10	0.18/0.25**	—
E 4135	0.33/0.38	0.70/0.90	0.025	0.025	0.20/0.35	—	0.80/1.10	0.18/0.25**	—
4137	0.35/0.40	0.70/0.90	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15/0.25	4137
E 4137	0.35/0.40	0.70/0.90	0.025	0.025	0.20/0.35	—	0.80/1.10	0.18/0.25	—
4140	0.38/0.43	0.75/1.00	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15/0.25	4140
4142	0.40/0.45	0.75/1.00	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15/0.25	—
4145	0.43/0.48	0.75/1.00	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15/0.25	4145
4147	0.45/0.50	0.75/1.00	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15/0.25	—
4150	0.48/0.53	0.75/1.00	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15/0.25	4150
4317	0.15/0.20	0.45/0.65	0.040	0.040	0.20/0.35	1.65/2.00	0.40/0.60	0.20/0.30	4317
4320	0.17/0.22	0.45/0.65	0.040	0.040	0.20/0.35	1.65/2.00	0.40/0.60	0.20/0.30	4320
4337	0.35/0.40	0.60/0.80	0.040	0.040	0.20/0.35	1.65/2.00	0.70/0.90	0.20/0.30	—
4340	0.38/0.43	0.60/0.80	0.040	0.040	0.20/0.35	1.65/2.00	0.70/0.90	0.20/0.30	4340
4608	0.06/0.11	0.25/0.45	0.040	0.040	0.25 Max.	1.40/1.75	—	0.15/0.25	4608
4615	0.13/0.18	0.45/0.65	0.040	0.040	0.20/0.35	1.65/2.00	—	0.20/0.30	4615
E 4617	0.15/0.20	0.45/0.65	0.025	0.025	0.20/0.35	1.65/2.00	—	0.20/0.27***	4617
4620	0.17/0.22	0.45/0.65	0.040	0.040	0.20/0.35	1.65/2.00	—	0.20/0.30	4620
X 4620	0.18/0.23	0.50/0.70	0.040	0.040	0.20/0.35	1.65/2.00	—	0.20/0.30	X 4620
E 4620	0.17/0.22	0.45/0.65	0.025	0.025	0.20/0.35	1.65/2.00	—	0.20/0.27	—
4621	0.18/0.23	0.70/0.90	0.040	0.040	0.20/0.35	1.65/2.00	—	0.20/0.30	4621
4640	0.38/0.43	0.60/0.80	0.040	0.040	0.20/0.35	1.65/2.00	—	0.20/0.30	4640
E 4640	0.38/0.43	0.60/0.80	0.025	0.025	0.20/0.35	1.65/2.00	—	0.20/0.27	—
TS 4720	0.17/0.22	0.50/0.70	0.040	0.040	—	0.90/1.20	0.35/0.55	0.15/0.25	—
4812	0.10/0.15	0.40/0.60	0.040	0.040	0.20/0.35	3.25/3.75	—	0.20/0.30	4812
4815	0.13/0.18	0.40/0.60	0.040	0.040	0.20/0.35	3.25/3.75	—	0.20/0.30	4815
4817	0.15/0.20	0.40/0.60	0.040	0.040	0.20/0.35	3.25/3.75	—	0.20/0.30	4817
4820	0.18/0.23	0.50/0.70	0.040	0.040	0.20/0.35	3.25/3.75	—	0.20/0.30	4820
5045	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	—	0.55/0.75	—	5045
5046	0.43/0.50	0.75/1.00	0.040	0.040	0.20/0.35	—	0.20/0.35	—	5046
5120	0.17/0.22	0.70/0.90	0.040	0.040	0.20/0.35	—	0.70/0.90	—	5120
5130	0.28/0.33	0.70/0.90	0.040	0.040	0.20/0.35	—	0.80/1.10	—	5130
5132	0.30/0.35	0.60/0.80	0.040	0.040	0.20/0.35	—	0.75/1.00	—	5132
5135	0.33/0.38	0.60/0.80	0.040	0.040	0.20/0.35	—	0.80/1.05	—	5135
5140	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	—	0.70/0.90	—	5140
5145	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	—	0.70/0.90	—	5145
5147	0.45/0.52	0.70/0.95	0.040	0.040	0.20/0.35	—	0.85/1.15	—	5147
5150	0.48/0.53	0.70/0.90	0.040	0.040	0.20/0.35	—	0.70/0.90	—	5150
5152	0.48/0.55	0.70/0.90	0.040	0.040	0.20/0.35	—	0.90/1.20	—	5152
5160	0.55/0.65	0.75/1.00	0.040	0.040	0.20/0.35	—	0.70/0.90	—	5160
E 50100	0.95/1.10	0.25/0.45	0.025	0.025	0.20/0.35	—	0.40/0.60	—	50100
E 51100	0.95/1.10	0.25/0.45	0.025	0.025	0.20/0.35	—	0.90/1.15	—	51100
E 52100	0.95/1.10	0.25/0.45	0.025	0.025	0.20/0.35	—	1.30/1.60	—	52100
6120	0.17/0.22	0.70/0.90	0.040	0.040	0.20/0.35	—	0.70/0.90	0.10 Min.	—
6145	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15 Min.	—
6150	0.48/0.53	0.70/0.90	0.040	0.040	0.20/0.35	—	0.80/1.10	0.15 Min.	6150
6152	0.48/0.55	0.70/0.90	0.040	0.040	0.20/0.35	—	0.80/1.10	0.10 Min.	—

(Continued)

Table 3A—(Concluded)

AISI Number	Chemical Composition Limits, per cent								Corre- spond- ing SAE Number
	C	Mn	P	S	Si	Ni	Cr	Mo	
8615	0.13/0.18	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8615
8617	0.15/0.20	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8617
8620	0.18/0.23	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8620
8622	0.20/0.25	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8622
8625	0.23/0.28	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8625
8627	0.25/0.30	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8627
8630	0.28/0.33	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8630
8632	0.30/0.35	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8632
8635	0.33/0.38	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8635
8637	0.35/0.40	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8637
8640	0.38/0.43	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8640
8641	0.38/0.43	0.75/1.00	0.040	0.040/0.060	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8641
8642	0.40/0.45	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8642
8645	0.43/0.48	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8645
8647	0.45/0.50	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8647
8650	0.48/0.53	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8650
8653	0.50/0.56	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.50/0.80	0.15/0.25	8653
8655	0.50/0.60	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8655
8660	0.55/0.65	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25	8660
8719	0.18/0.23	0.60/0.80	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	—
8720	0.18/0.23	0.70/0.90	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	8720
8735	0.33/0.38	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	8735
8740	0.38/0.43	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	8740
8742	0.40/0.45	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	—
8745	0.43/0.48	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	8745
8747	0.45/0.50	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	—
8750	0.48/0.53	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30	8750
9255	0.50/0.60	0.70/0.95	0.040	0.040	1.80/2.20	—	—	—	9255
9260	0.55/0.65	0.70/1.00	0.040	0.040	1.80/2.20	—	—	—	9260
9261	0.55/0.65	0.75/1.00	0.040	0.040	1.80/2.20	—	0.10/0.25	—	9261
9262	0.55/0.65	0.75/1.00	0.040	0.040	1.80/2.20	—	0.25/0.40	—	9262
E 9310	0.08/0.13	0.45/0.65	0.025	0.025	0.20/0.35	3.00/3.50	1.00/1.40	0.08/0.15	9310
E 9315	0.13/0.18	0.45/0.65	0.025	0.025	0.20/0.35	3.00/3.50	1.00/1.40	0.08/0.15	9315
E 9317	0.15/0.20	0.45/0.65	0.025	0.025	0.20/0.35	3.00/3.50	1.00/1.40	0.08/0.15	9317
9437	0.35/0.40	0.90/1.20	0.040	0.040	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15	9437
9440	0.38/0.43	0.90/1.20	0.040	0.040	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15	9440
9442	0.40/0.45	1.00/1.30	0.040	0.040	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15	9442
9445	0.43/0.48	1.00/1.30	0.040	0.040	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15	9445
9747	0.45/0.50	0.50/0.80	0.040	0.040	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25	9747
9763	0.60/0.67	0.50/0.80	0.040	0.040	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25	9763
9840	0.38/0.43	0.70/0.90	0.040	0.040	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30	9840
9845	0.43/0.48	0.70/0.90	0.040	0.040	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30	9845
9850	0.48/0.53	0.70/0.90	0.040	0.040	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30	9850

* For open hearth steel the manganese is 0.40 to 0.60 per cent.

** For open hearth steel the molybdenum is 0.15 to 0.25 per cent.

*** For open hearth steel the molybdenum is 0.20 to 0.30 per cent.

(Continued)

NOTES

NOTE 1. Grades shown in the above list with prefix letter E generally are manufactured by the basic electric furnace process. All others are normally manufactured by the basic open hearth process but may be manufactured by the basic electric furnace process with adjustments in phosphorus and sulphur.

NOTE 2. The phosphorus and sulphur limitations for each process are as follows:

Basic electric furnace	— 0.025 maximum per cent
Basic open hearth	— 0.04 maximum per cent
Acid electric furnace	— 0.05 maximum per cent
Acid open hearth	— 0.05 maximum per cent

NOTE 3. Minimum silicon limit for acid open hearth or acid electric furnace alloy steel is 0.15 per cent.

NOTE 4. Small quantities of certain elements are present in alloy steels which are not specified or required. These elements are considered as incidental and may be present to the following maximum amounts: Copper, 0.35 per cent; Nickel, 0.25 per cent; Chromium, 0.20 per cent and Molybdenum, 0.06 per cent.

NOTE 5. Where minimum and maximum sulphur content is shown it is indicative of resulphurized steels.

NOTE 6. Grades TS 4012 and TS 4720 are tentative standard steels.

CHEMICAL RANGES AND LIMITS FOR STEELS OTHER THAN STANDARD

It is recognized that compositions other than those listed in Table 3, Standard Steels, may at times be needed. When such steels are required, specifications for chemical composition are commonly prepared using the ranges and limits shown in Table 4.

Experience has shown that those ranges for chemical elements are necessary because of infrequent production and limited outlet. Because of infrequent production, the producer is generally unable to develop the necessary skill to furnish closer ranges with normal manufacturing practice. Moreover, because of the limited outlet for compositions of this type, it is not practicable, under normal manufacturing conditions, to furnish steel to closer ranges

because the difficulty of disposition of steel failing to meet such closer ranges increases the manufacturing risk.

Grades of alloy steel are commonly indicated by the percentages of the various elements which comprise their chemical composition, or by certain mechanical test values. For steel manufactured by any process, the elements comprising the desired chemical composition are specified in one of three ways:

1. By a maximum limit;
2. By a minimum limit;
3. By minimum and maximum limits, termed the *range*; by common usage, the range is the arithmetical difference between the two limits (e.g., 0.20/0.25 is a 0.05 range).

The chemical ranges and limits shown in Table 4 are subject to the standard variations for check analysis shown in Table 5, and to the standard methods of sampling for check analysis.

Small quantities of certain elements are present in alloy steels which are not specified or required. These elements are considered as incidental and may be present to the following maximum amounts: copper, 0.35 per cent; nickel, 0.25 per cent; chromium, 0.20 per cent; molybdenum, 0.06 per cent.

Table 4A

Chemical Ranges and Limits for Open Hearth and Electric Furnace Alloy Steels Other Than Standard

Subject to Variations for Check Analysis (Table 5)

Element	When Maximum of Specified Element is, per cent	Range Per Cent		Conventional Maximum Limit, Per Cent
		Open Hearth Steels	Electric Furnace Steels	
CARBON	To 0.25 incl.	0.06	0.05	
	Over 0.25 to 0.40 incl.	0.07	0.06	
	Over 0.40 to 0.55 incl.	0.08	0.07	
	Over 0.55 to 0.70 incl.	0.10	0.09	
	Over 0.70 to 0.95 incl.	0.12	0.11	
	Over 0.95 to 1.35 incl.	0.15	0.14	
MANGANESE	To 0.45 incl.	0.20	0.15	
	Over 0.45 to 0.80 incl.	0.25	0.20	
	Over 0.80 to 1.15 incl.	0.30	0.25	
	Over 1.15 to 1.65 incl.	0.35	0.30	
	Over 1.65 to 2.10 incl.	0.40	0.35	
PHOSPHORUS	Basic Open Hearth Steel			0.040
	Acid Open Hearth Steel			0.050
	Basic Electric Furnace Steel			0.025
	Acid Electric Furnace Steel			0.050
SULPHUR	To 0.060 incl.	0.02	0.02	
	Over 0.060 to 0.100 incl.	0.04	0.04	
	Over 0.100 to 0.140 incl.	0.05	0.05	
	Basic Open Hearth Steel			0.040
	Acid Open Hearth Steel			0.050
	Basic Electric Furnace Steel			0.025
	Acid Electric Furnace Steel			0.050
SILICON	To 0.15 incl.	0.08	0.08	
	Over 0.15 to 0.20 incl.	0.10	0.10	
	Over 0.20 to 0.35 incl.	0.15	0.15	
	Over 0.35 to 0.60 incl.	0.20	0.20	
	Over 0.60 to 1.00 incl.	0.30	0.30	
	Over 1.00 to 2.20 incl.	0.40	0.35	
	Acid Steels (Note 1)			

Table 4A (Concluded)

Element	When Maximum of Specified Element is, per cent	Range Per Cent	
		Open Hearth Steels	Electric Furnace Steels
NICKEL	To 0.50 incl.	0.20	0.20
	Over 0.50 to 1.50 incl.	0.30	0.30
	Over 1.50 to 2.00 incl.	0.35	0.35
	Over 2.00 to 3.00 incl.	0.40	0.40
	Over 3.00 to 5.30 incl.	0.50	0.50
	Over 5.30 to 10.00 incl.	1.00	1.00
CHROMIUM	To 0.40 incl.	0.20	0.15
	Over 0.40 to 0.80 incl.	0.25	0.20
	Over 0.80 to 1.05 incl.	0.30	0.25
	Over 1.05 to 1.25 incl.	0.35	0.30
	Over 1.25 to 1.75 incl.	0.50	0.40
	Over 1.75 to 3.99 incl.	0.60	0.50
MOLYBDENUM	To 0.10 incl.	0.05	0.05
	Over 0.10 to 0.20 incl.	0.07	0.07
	Over 0.20 to 0.40 incl.	0.10	0.10
	Over 0.40 to 0.80 incl.	0.15	0.15
	Over 0.80 to 1.15 incl.	0.20	0.20
TUNGSTEN	To 0.50 incl.	0.20	0.20
	Over 0.50 to 1.00 incl.	0.30	0.30
	Over 1.00 to 2.00 incl.	0.50	0.50
	Over 2.00 to 4.00 incl.	0.60	0.60
VANADIUM	To 0.25 incl.	0.05	0.05
	Over 0.25 to 0.50 incl.	0.10	0.10

NOTE 1. Minimum silicon limit for acid open hearth or acid electric furnace alloy steels is 0.15 per cent.

NOTE 2. Boron steels can be expected to have 0.0005 per cent minimum boron content.

STANDARD VARIATIONS FOR CHECK ANALYSES

When check analyses are to be made, the samples are taken in accordance with the Standard Methods for Sampling. Individual determinations sometimes vary from the specified limits or ranges to the extent shown in Table 5, but the several determinations of any individual element in a heat may not vary both above and below a specified range.

Table 5

STANDARD VARIATIONS FOR CHECK ANALYSIS OVER OR UNDER SPECIFIED RANGE OR LIMIT

Open Hearth and Electric Furnace Alloy Steels

Elements	Limit, or Maximum of Specified Element, per cent	Standard Variation: Over Maximum Limit or Under Minimum Limit
CARBON	To 0.30 incl.	0.01
	Over 0.30 to 0.75 incl.	0.02
	Over 0.75	0.03
MANGANESE	To 0.90 incl.	0.03
	Over 0.90 to 2.10 incl.	0.04
PHOSPHORUS	Over max. only	0.005
SULPHUR	To 0.060 incl.	0.005
SILICON	To 0.35 incl.	0.02
	Over 0.35 to 2.20 incl.	0.05
NICKEL	To 1.00 incl.	0.03
	Over 1.00 to 2.00 incl.	0.05
	Over 2.00 to 5.30 incl.	0.07
	Over 5.30 to 10.00 incl.	0.10
CHROMIUM	To 0.90 incl.	0.03
	Over 0.90 to 2.10 incl.	0.05
	Over 2.10 to 3.99	0.10
MOLYBDENUM	To 0.20 incl.	0.01
	Over 0.20 to 0.40 incl.	0.02
	Over 0.40 to 1.15 incl.	0.03
TUNGSTEN	To 1.00 incl.	0.04
	Over 1.00 to 4.00 incl.	0.08
VANADIUM	To 0.10 incl.	0.01
	Over 0.10 to 0.25 incl.	0.02
	Over 0.25 to 0.50 incl.	0.03
	Min. value specified, check under min. limit	0.01

STANDARD METHOD FOR SAMPLING FOR CHECK ANALYSIS

SAMPLING

Each heat of steel in a lot or shipment is considered separately. Representative samples are selected from the heat or lot.

When chips are taken by drilling, for pieces having a cross-sectional area up to 16 sq. in. inclusive, the diameter of the drill is approximately $\frac{1}{2}$ in.; for steel over 16 sq. in. cross-sectional area, the diameter of the drill is approximately 1 in. Each sample commonly consists of not less than 2 oz. of drillings.

Drillings or chips are taken without the application of water, oil or other lubricant, and must be free from scale, grease, dirt or other foreign substances. They should not be overheated during cutting to the extent of causing decarburization. Chips must be well mixed, and those too coarse to pass a No. 10 (2000 microns) sieve or too fine to remain on a No. 30 (590 microns) sieve are not suitable for proper analysis. Sieve size numbers are American Society for Testing Materials designations.

Steel subjected to certain heating operations by the purchaser may not give chemical analysis results which properly represent its original composition. Therefore, purchasers should analyze chips taken from the steel in the condition in which it is received from the steel producer.

When samples are returned to the producer of the steel for check analysis, the samples should consist of pieces of the full cross section if practicable, rather than chips.

Because of segregation, the location at which samples for check analysis are obtained is important. The following methods are recognized as standard for various sections:

1. Applicable to small sections whose cross-sectional area does not exceed 0.75 sq. in., such as rounds, squares, hexagons, etc. Chips are taken by milling or machining the full cross section of the piece.

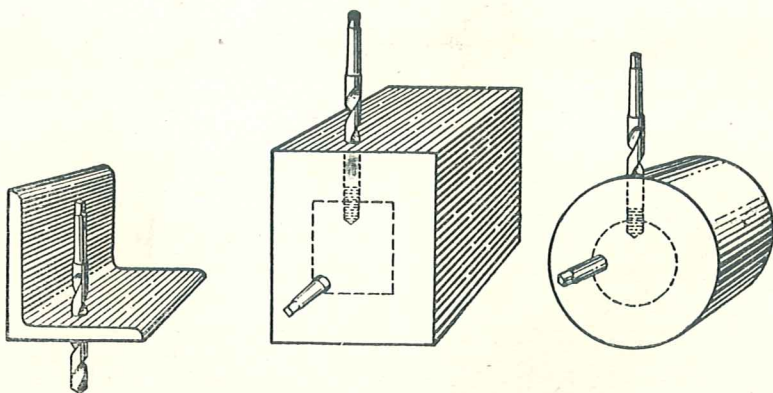


Fig. 1—Drill Locations for Sampling

2. Applicable to products where the width of the cross section greatly exceeds the thickness, such as bar size shapes, and light flat bars. Chips are taken by drilling entirely through the steel at a point midway between the edge and the middle of the section, or by milling or machining the entire cross section. See Fig. 1.
3. Applicable to large sections, such as rounds, squares, etc. Chips are taken at any point midway between the outside and the center of the piece by drilling parallel to the axis. In cases where this method is not practicable, the piece may be drilled on the side, but chips are not taken until they represent the portion midway between the outside and the center. See Fig. 1.

ANALYTICAL PROCEDURE

Methods of Analysis commonly used are in accordance with the latest edition of *Methods of Chemical Analysis of Metals*, published by the American Society for Testing Materials, or the methods approved by the National Bureau of Standards, or methods of equivalent accuracy.

Part V

**H-STEELS AND HARDENABILITY
REQUIREMENTS**

Part V

H-STEELS AND HARDENABILITY REQUIREMENTS

FOREWORD

As a result of cooperative work done by the Society of Automotive Engineers Iron and Steel Technical Committee—Division III, and the Technical Committee on Alloy Steel Bars of the American Iron and Steel Institute, hardenability bands have been devised which are considered satisfactory for use in describing certain characteristics of constructional alloy steels. The hardenability limits and their conditions of use as set forth herein were determined by the standard 1-inch end quench hardenability test.

Tentative hardenability bands for use with the H-steels were previously published as Contributions to the Metallurgy of Steel—No. 11, in July, 1944; a second edition in January, 1947, and the latest edition issued in May, 1949. The June, 1945 issue of Section 10, Steel Products Manual, also contained the H-steels and corresponding hardenability bands. By joint action of the above committees, the H-steels and corresponding hardenability bands now have been removed from the tentative status. There have been many improvements in the hardenability bands and some changes in shape resulting from experience gained during the past four years. The minimum and maximum hardenability limits for each of the H-steels are shown herein as tabular values of Rockwell C hardness. These values are rounded off to the nearest full hardness value and are used for specification purposes. The latest edition of Contributions to the Metallurgy of Steel—No. 11 contains the hardenability bands in graphical form as well as the tabular hardness values.

The above-mentioned Committees will continue to collect and compile all information on steels furnished to these hardenability limits to determine what further modifications are possible or necessary.

GRADES OF STEEL

H-steels and their corresponding minimum and maximum hardenability limits are shown for all of the standard steels of Table 3, Part IV, for which there were sufficient hardenability data, and only for those grades where the standard end quench test can be used. As information is accumulated on other grades, this publication will be supplemented.

CHEMICAL COMPOSITION LIMITS

In order to afford steel producers the latitude in manufacturing operations necessary to meet a common standard of hardenability limits, the chemical composition limits of these steels have been modified somewhat from the ranges or limits applicable to the same grades when specified by chemical composition only. These modifications permit adjustments in manufacturing ranges of chemistry to correct for individual plant melting characteristics which might otherwise influence the levels and widths of the bands. The modifications have not been great enough to influence the general characteristics of the original compositions of the series under consideration.

The chemical composition limits for both electric furnace and open hearth steels are outlined in Table 6 and are subject to the variations for check analysis outlined in Table 7.

IDENTIFICATION

As a means of identifying steels specified to hardenability band limits, the suffix letter H has been added to the conventional series number. It is quite important that purchasers use the suffix letter in specification requirements as there is no other means of determining when hardenability band limits apply. When the suffix letter is used all the conditions pertaining to chemical composition limits, testing technique, etc., as outlined herein apply.

GRAIN SIZE

The limits set forth for bands are intended to apply to steels manufactured to fine grain steel practice. In cases where coarse grain steel is desired, the hardenability limits are negotiated between purchaser and producer.

USE OF HARDENABILITY LIMITS

Tables 8 to 24, inclusive, show the minimum and maximum hardness values (Rockwell C) at the corresponding distances from the quenched end of the standard end quench test bar for all of the H-steels. Values from these tables should be used for specification purposes and it is recommended that two points be used to designate the hardenability. Those two points may be designated in any one of the following ways.

A. The minimum and maximum hardness values at any desired distance. This method is illustrated on page 74 as points A-A and would be specified as J39/52 equals 4 sixteenths. Obviously the distance selected would be that distance on the end quench test bar which corresponds to the section used by the purchaser.

B. The minimum and maximum distances at which any desired hardness value occurs. This method is illustrated on page 74 as points B-B and would be specified as J42 equals 3 to 8 sixteenths. If the desired hardness does not fall on an exact sixteenth position, the minimum distance selected should be the nearest sixteenth position toward the quenched end and the maximum should be the nearest sixteenth position away from the quenched end.

C. Two maximum hardness values at two desired distances, illustrated on page 74 as points C-C.

D. Two minimum hardness values at two desired distances, illustrated on page 74 as points D-D.

E. Any minimum hardness plus any maximum hardness.

Note 1. In cases where it is considered desirable, the maximum and minimum limits at the 1/16 in. point can be specified in addition to the other two points.

Note 2. In cases where it is necessary to specify more than two points on the hardenability band (exclusive of the maximum and minimum limits at 1/16 in.) a tolerance of two points Rockwell C over any small portion of either curve (except at 1/16 in.) is customary. This is necessary because it will be found that curves of individual heats may vary somewhat in shape from the standard band limits and thus may deviate slightly at one or two positions if the full length of the curves is specified. The hardenability specification should be based upon one of the following:

- a. Two specific points on the hardenability band (plus 1/16 in. limits if desired), in which case the tolerance described above does not apply;
- b. More than two specific points up to the entire hardenability band, in which case the tolerance described above does apply.

Method (a) is usually preferred as most pertinent.

GENERAL

The steel producer should show on the proper shipping papers or by some other acceptable means the hardenability characteristics of the heat involved when an H-steel is specified. The heat hardenability should be shown either by hardness values at specified reference points or by hardness values at the following distances from the quenched end of the test specimen: $\frac{1}{16}$ in.; $\frac{1}{8}$ in.; $\frac{1}{4}$ in.; $\frac{1}{2}$ in.; $\frac{3}{4}$ in.; 1 in.; $1\frac{1}{4}$ in.; $1\frac{1}{2}$ in.; $1\frac{3}{4}$ in.; 2 in. No reading below 20 Rockwell C is ordinarily reported. The heat hardenability is determined from either a cast or a forged end quench hardenability test bar.

The technique of testing for acceptance is in accordance with the provisions outlined in Part II, Standard End Quench Hardenability Test Procedure, in Contributions to the Metallurgy of Steel—No. 11 of latest issue. This procedure was adapted from Society of Automotive Engineers, "Method of Determining Hardenability—SAE Recommended Practice," as published in the 1949 SAE Handbook.

R. F. SELL

Table 6A
H-STEELS
Chemical Composition Ranges
Open Hearth and Electric Furnace Steels
Bars — Billets — Blooms

The ranges and limits in this table apply to material not exceeding 200 sq. inches in cross-sectional area, or 18 inches in width, or 10,000 lb. in weight, per piece.

Steel Designation SAE or ASTM	Chemical Composition, Per Cent					
	C	Mn	Si	Ni	Cr	Mo
1320 H	0.17/0.24	1.50/2.00	0.20/0.35	—	—	—
1330 H	0.27/0.34	1.50/2.00	0.20/0.35	—	—	—
1335 H	0.32/0.39	1.50/2.00	0.20/0.35	—	—	—
1340 H	0.37/0.45	1.50/2.00	0.20/0.35	—	—	—
2330 H	0.27/0.34	0.55/0.85	0.20/0.35	3.20/3.80	—	—
2512 H	0.08/0.15	0.35/0.65	0.20/0.35	4.70/5.30	—	—
2515 H	0.11/0.18	0.35/0.65	0.20/0.35	4.70/5.30	—	—
2517 H	0.14/0.21	0.35/0.65	0.20/0.35	4.70/5.30	—	—
3120 H	0.17/0.24	0.55/0.85	0.20/0.35	1.00/1.50	0.50/0.80	—
3130 H	0.27/0.34	0.55/0.85	0.20/0.35	1.00/1.50	0.50/0.80	—
3135 H	0.32/0.39	0.55/0.85	0.20/0.35	1.00/1.50	0.50/0.80	—
3140 H	0.37/0.45	0.60/0.95	0.20/0.35	1.00/1.50	0.50/0.80	—
3310 H	0.07/0.14	0.35/0.65	0.20/0.35	3.20/3.80	1.35/1.75	—
3316 H	0.13/0.20	0.35/0.65	0.20/0.35	3.20/3.80	1.35/1.75	—
4032 H	0.30/0.37	0.60/0.95	0.20/0.35	—	—	0.20/0.30
4037 H	0.35/0.43	0.60/0.95	0.20/0.35	—	—	0.20/0.30
4042 H	0.40/0.48	0.60/0.95	0.20/0.35	—	—	0.20/0.30
4047 H	0.44/0.52	0.60/0.95	0.20/0.35	—	—	0.20/0.30
4053 H	0.49/0.57	0.70/1.05	0.20/0.35	—	—	0.20/0.30
4063 H	0.59/0.69	0.70/1.05	0.20/0.35	—	—	0.20/0.30
4068 H	0.62/0.72	0.70/1.05	0.20/0.35	—	—	0.20/0.30
4130 H	0.27/0.34	0.35/0.65	0.20/0.35	—	0.80/1.15	0.15/0.25
4132 H	0.30/0.37	0.35/0.65	0.20/0.35	—	0.80/1.15	0.15/0.25
4135 H	0.32/0.39	0.60/0.95	0.20/0.35	—	0.80/1.15	0.15/0.25
4137 H	0.35/0.43	0.60/0.95	0.20/0.35	—	0.80/1.15	0.15/0.25
4140 H	0.37/0.45	0.70/1.05	0.20/0.35	—	0.80/1.15	0.15/0.25
4142 H	0.40/0.48	0.70/1.05	0.20/0.35	—	0.80/1.15	0.15/0.25
4145 H	0.42/0.50	0.70/1.05	0.20/0.35	—	0.80/1.15	0.15/0.25
4147 H	0.44/0.52	0.70/1.05	0.20/0.35	—	0.80/1.15	0.15/0.25
4150 H	0.46/0.54	0.70/1.05	0.20/0.35	—	0.80/1.15	0.15/0.25
4317 H	0.14/0.21	0.40/0.70	0.20/0.35	1.50/2.00	0.35/0.65	0.20/0.30
4320 H	0.16/0.23	0.40/0.70	0.20/0.35	1.50/2.00	0.35/0.65	0.20/0.30
4337 H	0.35/0.43	0.55/0.85	0.20/0.35	1.50/2.00	0.65/0.95	0.20/0.30
4340 H	0.37/0.45	0.60/0.95	0.20/0.35	1.50/2.00	0.65/0.95	0.20/0.30
4620 H	0.17/0.24	0.40/0.70	0.20/0.35	1.50/2.00	—	0.20/0.30
X4620 H	0.17/0.24	0.45/0.75	0.20/0.35	1.50/2.00	—	0.20/0.30
4621 H	0.17/0.24	0.60/0.95	0.20/0.35	1.50/2.00	—	0.20/0.30
4640 H	0.37/0.45	0.55/0.85	0.20/0.35	1.50/2.00	—	0.20/0.30
4812 H	0.10/0.17	0.30/0.60	0.20/0.35	3.20/3.80	—	0.20/0.30
4815 H	0.12/0.19	0.35/0.65	0.20/0.35	3.20/3.80	—	0.20/0.30
4817 H	0.14/0.21	0.35/0.65	0.20/0.35	3.20/3.80	—	0.20/0.30
4820 H	0.17/0.24	0.45/0.75	0.20/0.35	3.20/3.80	—	0.20/0.30
5120 H	0.17/0.24	0.60/0.95	0.20/0.35	—	0.65/0.95	—
5130 H	0.27/0.34	0.60/0.95	0.20/0.35	—	0.80/1.15	—
5132 H	0.28/0.35	0.50/0.85	0.20/0.35	—	0.70/1.05	—
5135 H	0.32/0.39	0.55/0.85	0.20/0.35	—	0.75/1.10	—
5140 H	0.37/0.45	0.60/0.95	0.20/0.35	—	0.65/0.95	—
5145 H	0.42/0.50	0.60/0.95	0.20/0.35	—	0.65/0.95	—
5147 H	0.44/0.52	0.65/1.00	0.20/0.35	—	0.85/1.20	—
5150 H	0.46/0.54	0.60/0.95	0.20/0.35	—	0.65/0.95	—
5152 H	0.48/0.56	0.60/0.95	0.20/0.35	—	0.90/1.25	—
5160 H	0.55/0.65	0.70/1.05	0.20/0.35	—	0.65/0.95	—

Table 6A (Concluded)

Steel Designation SAE or AISI	Chemical Composition, Per Cent					
	C	Mn	Si	Ni	Cr	Mo
6150 H	0.46/0.54	0.60/0.95	0.20/0.35	—	0.80/1.15	(0.15 Min. V)
8617 H	0.14/0.21	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8620 H	0.17/0.24	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8622 H	0.20/0.27	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8625 H	0.22/0.29	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8627 H	0.25/0.32	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8630 H	0.27/0.34	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8632 H	0.30/0.37	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8635 H	0.32/0.39	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8637 H	0.35/0.43	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8640 H	0.37/0.45	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8641 H*	0.37/0.45	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8642 H	0.40/0.48	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8645 H	0.42/0.50	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8647 H	0.44/0.52	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8650 H	0.46/0.54	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8653 H	0.49/0.57	0.70/1.05	0.20/0.35	0.35/0.75	0.50/0.85	0.15/0.25
8655 H	0.50/0.60	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8660 H	0.55/0.65	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.15/0.25
8720 H	0.17/0.24	0.60/0.95	0.20/0.35	0.35/0.75	0.35/0.65	0.20/0.30
8735 H	0.32/0.39	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.20/0.30
8740 H	0.37/0.45	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.20/0.30
8742 H	0.40/0.48	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.20/0.30
8745 H	0.42/0.50	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.20/0.30
8747 H	0.44/0.52	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.20/0.30
8750 H	0.46/0.54	0.70/1.05	0.20/0.35	0.35/0.75	0.35/0.65	0.20/0.30
9260 H	0.55/0.65	0.70/1.05	1.70/2.20	—	—	—
9261 H	0.55/0.65	0.70/1.05	1.70/2.20	—	0.05/0.35	—
9262 H	0.55/0.65	0.70/1.05	1.70/2.20	—	0.20/0.50	—
9310 H	0.07/0.14	0.40/0.70	0.20/0.35	2.95/3.55	1.00/1.45	0.08/0.15
9437 H	0.35/0.43	0.85/1.25	0.20/0.35	0.25/0.65	0.25/0.55	0.08/0.15
9440 H	0.37/0.45	0.85/1.25	0.20/0.35	0.25/0.65	0.25/0.55	0.08/0.15
9442 H	0.40/0.48	0.95/1.35	0.20/0.35	0.25/0.65	0.25/0.55	0.08/0.15
9445 H	0.42/0.50	0.95/1.35	0.20/0.35	0.25/0.65	0.25/0.55	0.08/0.15

* Sulphur content 0.040/0.060 per cent.

NOTE 1. Phosphorus and sulphur in open hearth steel is 0.040 per cent max. Phosphorus and sulphur in electric furnace steel is 0.025 per cent max.

NOTE 2. Small quantities of certain elements are present in alloy steels which are not specified or required. These elements are considered as incidental and may be present to the following maximum amounts: Copper, 0.35 per cent; Nickel, 0.25 per cent; Chromium, 0.20 per cent; Molybdenum, 0.06 per cent.

NOTE 3. The chemical ranges and limits shown in Table 19 are subject to the standard variations for check analysis shown in Table 20.

Table 7

**STANDARD VARIATIONS FOR CHECK ANALYSIS
OVER OR UNDER SPECIFIED RANGE OR LIMIT
APPLICABLE TO H-STEELS**

Open Hearth and Electric Furnace Steels

Elements	Limit, or Maximum of Specified Element, Per Cent	Standard Variation: Over Maximum Limit or Under Minimum Limit
CARBON	To 0.25 incl.	0.01
	Over 0.25 to 0.75 incl.	0.02
MANGANESE	To 0.90 incl.	0.03
	Over 0.90 to 2.10 incl.	0.04
PHOSPHORUS	Over max. only	0.005
SULPHUR	To 0.060 incl.	0.005
SILICON	To 0.35 incl.	0.02
	Over 0.35 to 2.20 incl.	0.05
NICKEL	To 1.00 incl.	0.03
	Over 1.00 to 2.00 incl.	0.05
	Over 2.00 to 5.30 incl.	0.07
CHROMIUM	To 0.90 incl.	0.03
	Over 0.90 to 2.10 incl.	0.05
MOLYBDENUM	To 0.20 incl.	0.01
	Over 0.20 to 0.40 incl.	0.02
VANADIUM	Min. value specified Check under minimum limit	0.01

Table 8A

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits* — 1300 H

"J" Distance Inches	G R A D E							
	1320 H		1330 H		1335 H		1340 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	48	40	54	46	57	49	60	52
1/8	47	37	54	46	57	49	60	52
3/16	46	32	53	43	56	47	59	51
1/4	45	28	52	40	55	44	58	49
5/16	42	23	51	35	54	38	57	46
3/8	39	21	50	31	52	34	56	40
7/16	36	—	48	28	50	31	55	35
1/2	33	—	45	26	48	29	54	33
9/16	32	—	43	25	46	27	52	31
5/8	30	—	42	23	44	26	51	29
11/16	29	—	40	22	42	25	50	28
3/4	28	—	39	21	41	24	48	27
13/16	28	—	38	20	40	23	46	26
7/8	27	—	37	—	39	22	44	25
15/16	26	—	36	—	38	22	42	25
1	26	—	35	—	37	21	41	24
1-1/8	25	—	34	—	35	20	39	23
1-1/4	24	—	33	—	34	—	38	23
1-3/8	23	—	32	—	33	—	37	22
1-1/2	23	—	31	—	32	—	36	22
1-5/8	22	—	31	—	31	—	35	21
1-3/4	22	—	31	—	31	—	35	21
1-7/8	22	—	30	—	30	—	34	20
2	21	—	30	—	30	—	34	20

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 9

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits* — 2300 H

"J" Distance Inches	GRADE	
	2330 H	
	Max.	Min.
1/16	54	46
1/8	54	46
3/16	53	45
1/4	52	42
5/16	51	38
3/8	50	34
7/16	48	30
1/2	46	27
9/16	44	24
5/8	42	22
11/16	40	21
3/4	38	20
13/16	37	—
7/8	35	—
15/16	34	—
1	33	—
1-1/8	31	—
1-1/4	30	—
1-3/8	29	—
1-1/2	29	—
1-5/8	29	—
1-3/4	29	—
1-7/8	28	—
2	28	—

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 10

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits* — 2500 H

"J" Distance Inches	GRADE					
	2512 H		2515 H		2517 H	
	Max.	Min.	Max.	Min.	Max.	Min.
1/16	43	36	45	37	46	39
1/8	43	34	44	37	46	38
3/16	42	30	43	33	46	35
1/4	41	26	42	30	45	31
5/16	39	23	41	27	44	28
3/8	37	21	40	24	43	25
7/16	36	—	38	22	42	23
1/2	34	—	37	20	41	21
9/16	32	—	35	—	39	20
5/8	31	—	34	—	37	—
11/16	29	—	32	—	35	—
3/4	28	—	31	—	34	—
13/16	27	—	30	—	33	—
7/8	26	—	29	—	32	—
15/16	25	—	29	—	32	—
1	25	—	28	—	31	—
1-1/8	24	—	27	—	30	—
1-1/4	23	—	26	—	29	—
1-3/8	23	—	25	—	28	—
1-1/2	22	—	24	—	27	—
1-5/8	22	—	24	—	27	—
1-3/4	21	—	23	—	26	—
1-7/8	21	—	23	—	26	—
2	20	—	22	—	25	—

*These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 11

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits* — 3100 H

"J" Distance Inches	GRADE							
	3120 H		3130 H		3135 H		3140 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	48	40	54	46	57	49	60	52
1/8	47	39	54	46	57	49	60	51
3/16	44	34	53	44	56	48	59	50
1/4	42	30	52	42	55	47	59	49
5/16	38	25	51	38	54	44	58	47
3/8	35	23	49	34	53	41	57	45
7/16	32	21	48	32	51	37	57	43
1/2	30	20	45	30	50	35	56	41
9/16	29	—	43	29	48	33	55	38
5/8	28	—	41	28	46	31	54	36
11/16	27	—	39	26	44	30	53	34
3/4	27	—	38	25	42	29	52	33
13/16	26	—	36	25	40	29	51	32
7/8	26	—	35	24	39	28	50	31
15/16	25	—	34	23	38	27	49	30
1	25	—	34	22	37	26	48	30
1-1/8	24	—	33	21	36	25	46	29
1-1/4	23	—	32	20	35	23	44	28
1-3/8	23	—	32	—	34	22	43	28
1-1/2	22	—	31	—	34	20	42	27
1-5/8	22	—	31	—	34	—	41	27
1-3/4	21	—	31	—	34	—	40	26
1-7/8	21	—	30	—	33	—	40	26
2	21	—	30	—	33	—	39	25

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 12

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits* — 3300 H

"J" Distance Inches	GRADE			
	3310 H		3316 H	
	Max.	Min.	Max.	Min.
1/16	43	35	48	40
1/8	42	35	47	39
3/16	42	35	47	38
1/4	42	35	46	38
5/16	42	34	46	37
3/8	42	33	46	37
7/16	41	32	45	36
1/2	41	31	45	35
9/16	41	30	45	34
5/8	40	30	45	33
11/16	40	29	45	33
3/4	40	29	45	32
13/16	39	28	45	32
7/8	39	28	44	32
15/16	38	27	44	31
1	38	27	44	31
1-1/8	37	26	44	31
1-1/4	37	26	43	31
1-3/8	37	26	43	31
1-1/2	36	26	43	31
1-5/8	36	25	42	31
1-3/4	36	25	42	30
1-7/8	35	25	42	30
2	35	25	41	30

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 13A — END-QUENCH HARDENABILITY BANDS — *Tabulation of Band Limits** — 4000 H

	"J" Distance Inches	GRADE											
		4032 H		4037 H		4042 H		4047 H		4053 H		4063 H	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	1/16	56	48	59	51	62	54	64	56	65	59	—	60
	1/8	54	45	57	49	60	52	62	55	65	59	—	60
	3/16	51	36	54	42	58	48	60	50	64	57	65	60
	1/4	46	29	51	35	55	40	58	42	62	53	65	59
	5/16	39	25	45	30	50	33	55	35	61	45	65	56
	3/8	34	23	38	26	45	29	52	32	59	38	64	45
	7/16	31	22	34	23	39	27	47	30	57	34	62	39
	1/2	29	21	32	22	36	26	43	28	55	32	61	36
	9/16	28	20	30	21	34	25	40	28	51	31	59	35
	5/8	26	—	29	20	33	24	38	27	47	30	57	34
	11/16	26	—	28	—	32	24	37	26	44	29	54	33
	3/4	25	—	27	—	31	23	35	26	42	29	51	33
	13/16	24	—	26	—	30	23	34	25	40	28	48	33
	7/8	24	—	26	—	30	23	33	25	38	28	46	32
	15/16	23	—	26	—	29	22	33	25	37	28	44	32
	1	23	—	25	—	29	22	32	25	36	28	43	32
	1-1/8	23	—	25	—	28	22	31	24	34	27	41	31
	1-1/4	22	—	25	—	28	21	30	24	33	27	40	31
	1-3/8	22	—	25	—	28	20	30	23	33	27	39	30
	1-1/2	21	—	24	—	27	20	30	23	32	26	38	30
	1-5/8	21	—	24	—	27	—	30	22	32	26	38	29
	1-3/4	20	—	24	—	27	—	29	22	32	26	37	29
	1-7/8	—	—	23	—	26	—	29	21	31	25	37	28
	2	—	—	23	—	26	—	29	21	31	25	36	28

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 14
END-QUENCH HARDENABILITY BANDS
Tabulation of Band Limits* — 4100 H

"J" Distance Inches	GRADE																	
	4130 H		4132 H		4135 H		4137 H		4140 H		4142 H		4145 H		4147 H		4150 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	54	46	56	48	57	50	59	51	60	52	62	54	63	55	64	56	65	58
1/8	54	45	55	47	57	50	58	51	60	52	62	54	63	55	64	56	65	58
3/16	53	42	55	45	57	49	58	50	60	52	62	54	62	54	64	56	65	58
1/4	51	38	54	42	56	48	57	49	59	51	61	53	62	54	64	56	65	58
5/16	49	34	52	37	56	47	57	49	59	51	61	53	62	53	63	55	65	58
3/8	47	31	50	34	55	45	56	48	58	50	61	52	61	53	63	55	65	57
7/16	44	29	47	32	54	42	55	45	58	48	60	51	61	52	63	55	65	57
1/2	42	27	45	31	53	40	55	43	57	47	60	50	61	52	63	54	64	56
9/16	40	26	43	30	52	38	55	40	57	44	60	49	60	51	63	54	64	56
5/8	38	26	41	29	51	36	54	39	56	42	59	47	60	50	62	53	64	55
11/16	36	25	39	28	50	34	53	37	56	40	59	46	60	49	62	52	64	54
3/4	35	25	38	28	49	33	52	36	55	39	58	44	59	48	62	51	63	53
13/16	34	24	37	27	48	32	51	35	55	38	58	42	59	46	61	49	63	51
7/8	34	24	37	27	47	31	50	34	54	37	57	41	59	45	61	48	62	50
15/16	33	23	36	26	46	30	49	33	54	36	57	40	58	43	60	46	62	48
1	33	23	36	26	45	30	48	33	53	35	56	39	58	42	60	45	62	47
1-1/8	32	22	35	25	44	29	46	32	52	34	55	37	57	40	59	42	61	45
1-1/4	32	21	34	24	42	28	45	31	51	33	54	36	57	38	59	40	60	43
1-3/8	32	20	33	23	41	27	44	30	49	33	53	35	56	37	58	39	59	41
1-1/2	31	—	33	22	40	27	43	30	48	32	53	34	55	36	57	38	59	40
1-5/8	31	—	33	21	39	27	42	30	47	32	52	34	55	35	57	37	58	39
1-3/4	30	—	32	21	38	26	42	29	46	31	51	34	55	35	57	37	58	38
1-7/8	30	—	32	20	38	26	41	29	45	31	51	33	55	34	56	37	58	38
2	29	—	32	20	37	26	41	29	44	30	50	33	54	34	56	36	58	38

Table 15

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits* — 4300 H

"J" Distance Inches	GRADE							
	4317 H		4320 H		4337 H		4340 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	46	39	48	40	59	51	60	52
1/8	45	35	47	38	59	51	60	52
3/16	43	31	45	35	58	51	60	52
1/4	41	29	43	32	58	51	60	52
5/16	38	26	41	29	58	51	60	52
3/8	36	24	38	27	58	51	60	52
7/16	33	21	36	25	58	51	60	52
1/2	31	20	34	23	58	50	60	52
9/16	29	—	33	22	58	50	60	52
5/8	28	—	31	21	57	50	60	52
11/16	27	—	30	20	57	50	59	51
3/4	26	—	29	20	57	49	59	51
13/16	26	—	28	—	57	48	59	50
7/8	25	—	27	—	57	47	58	49
15/16	24	—	27	—	57	46	58	49
1	24	—	26	—	57	46	58	48
1-1/8	23	—	25	—	56	44	58	47
1-1/4	22	—	25	—	56	42	57	46
1-3/8	22	—	24	—	55	41	57	45
1-1/2	22	—	24	—	55	40	57	44
1-5/8	22	—	24	—	55	39	57	43
1-3/4	22	—	24	—	54	39	56	42
1-7/8	22	—	24	—	54	39	56	41
2	22	—	24	—	53	39	56	40

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 16

END-QUENCH HARDENABILITY BANDS*Tabulation of Band Limits* — 4600 H*

"J" Distance Inches	GRADE							
	4620 H		X4620 H		4621 H		4640 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	48	40	48	40	48	40	60	52
1/8	45	35	46	38	47	38	60	52
3/16	42	27	44	30	46	34	59	51
1/4	39	24	41	26	44	30	58	50
5/16	34	21	36	23	41	27	57	48
3/8	31	—	32	21	37	25	56	44
7/16	29	—	30	—	34	23	55	41
1/2	27	—	28	—	32	22	53	37
9/16	26	—	27	—	30	20	51	34
5/8	25	—	26	—	28	—	49	32
11/16	24	—	25	—	27	—	46	30
3/4	23	—	24	—	26	—	44	29
13/16	22	—	24	—	26	—	42	28
7/8	22	—	23	—	25	—	41	27
15/16	22	—	23	—	25	—	40	27
1	21	—	23	—	24	—	39	27
1-1/8	21	—	22	—	24	—	38	26
1-1/4	20	—	21	—	23	—	37	26
1-3/8	—	—	21	—	23	—	36	26
1-1/2	—	—	20	—	22	—	35	25
1-5/8	—	—	—	—	22	—	35	25
1-3/4	—	—	—	—	22	—	34	25
1-7/8	—	—	—	—	21	—	34	24
2	—	—	—	—	21	—	33	24

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 17

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits* — 4800 H

"J" Distance Inches	GRADE							
	4812 H		4815 H		4817 H		4820 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	44	37	45	38	46	39	48	40
1/8	43	34	44	37	46	38	48	40
3/16	42	30	44	34	45	35	47	39
1/4	41	26	42	30	44	32	46	38
5/16	39	23	41	27	42	29	45	34
3/8	37	21	39	24	41	27	43	31
7/16	35	—	37	22	39	25	42	29
1/2	33	—	35	21	37	23	40	27
9/16	31	—	33	20	35	22	39	26
5/8	29	—	31	—	33	21	37	25
11/16	28	—	30	—	32	20	36	24
3/4	27	—	29	—	31	20	35	23
13/16	26	—	28	—	30	—	34	22
7/8	25	—	28	—	29	—	33	22
15/16	25	—	27	—	28	—	32	21
1	24	—	27	—	28	—	31	21
1-1/8	24	—	26	—	27	—	29	20
1-1/4	23	—	25	—	26	—	28	20
1-3/8	23	—	24	—	25	—	28	—
1-1/2	22	—	24	—	25	—	27	—
1-5/8	22	—	24	—	25	—	27	—
1-3/4	21	—	23	—	25	—	26	—
1-7/8	21	—	23	—	24	—	26	—
2	21	—	23	—	24	—	25	—

*These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 18A — END-QUENCH HARDENABILITY BANDS — Tabulation of Band Limits* — 5100 H

"J" Distance Inches	GRADE																															
	5120 H		5130 H		5132 H		5135 H		5140 H		5145 H		5147 H		5150 H		5152 H		5160 H													
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.											
1/16	48	39	54	46	55	47	57	49	60	52	63	55	64	56	65	58	65	59	—	60												
1/8	46	34	54	46	54	46	57	49	59	52	62	54	64	56	65	58	65	58	—	60												
3/16	41	28	53	42	53	43	56	47	58	50	61	53	63	55	64	57	65	58	—	60												
1/4	36	23	51	39	52	40	55	43	57	48	60	51	62	54	63	56	64	57	65	59												
5/16	33	20	49	35	50	35	54	38	56	43	59	48	62	53	62	53	63	56	65	58												
3/8	30	—	47	32	48	32	52	35	54	38	58	42	61	52	61	49	63	55	64	56												
7/16	28	—	45	30	45	29	50	32	52	35	57	38	61	49	60	42	62	53	64	52												
1/2	27	—	42	28	42	27	47	30	50	33	56	35	60	45	59	38	62	51	63	47												
9/16	25	—	40	26	40	25	45	28	48	31	55	33	60	40	58	36	61	48	62	42												
5/8	24	—	38	25	38	24	43	27	46	30	53	32	59	37	56	34	60	45	61	39												
11/16	23	—	37	23	37	23	41	25	45	29	52	31	59	35	55	33	60	42	60	37												
3/4	22	—	36	22	36	22	40	24	43	28	50	30	58	34	53	32	59	39	59	36												
13/16	21	—	35	21	35	21	39	23	42	27	48	30	58	33	51	31	59	38	58	35												
7/8	21	—	34	20	34	20	38	22	40	27	47	29	57	32	50	31	58	37	56	35												
15/16	20	—	34	—	34	—	37	21	39	26	45	28	57	32	48	30	58	36	54	34												
1	—	—	33	—	33	—	37	21	38	25	44	28	56	31	47	30	57	35	52	34												
1-1/8	—	—	32	—	32	—	36	20	37	24	42	26	55	30	45	29	56	34	48	33												
1-1/4	—	—	31	—	31	—	35	—	36	23	41	25	54	29	43	28	55	32	47	32												
1-3/8	—	—	30	—	30	—	34	—	35	21	39	23	53	27	42	27	53	31	46	31												
1-1/2	—	—	29	—	29	—	33	—	34	20	38	23	52	26	41	26	51	30	45	30												
1-5/8	—	—	27	—	28	—	32	—	34	—	37	22	51	25	40	25	50	29	44	29												
1-3/4	—	—	26	—	27	—	32	—	33	—	37	21	50	24	39	24	48	27	43	28												
1-7/8	—	—	25	—	26	—	31	—	33	—	36	—	49	22	39	23	47	26	43	28												
2	—	—	24	—	25	—	30	—	32	—	35	—	48	21	38	22	45	25	42	27												

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 19

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits — 6100 H*

"J" Distance Inches	GRADE	
	6150 H	
	Max.	Min.
1/16	65	58
1/8	65	58
3/16	64	57
1/4	63	56
5/16	63	54
3/8	62	51
7/16	61	48
1/2	60	45
9/16	59	43
5/8	58	40
11/16	57	38
3/4	56	36
13/16	55	35
7/8	54	35
15/16	52	34
1	51	34
1-1/8	48	33
1-1/4	46	32
1-3/8	45	30
1-1/2	44	29
1-5/8	43	28
1-3/4	42	27
1-7/8	41	26
2	40	25

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 20
END-QUENCH HARDENABILITY BANDS
Tabulation of Band Limits* — 8600 H

"J" Distance Inches	GRADE																																	
	8620 H 2nd Rev.				8622 H		8625 H		8627 H		8630 H		8632 H		8635 H		8637 H		8640 H 8641 H		8642 H		8645 H		8647 H		8650 H		8653 H		8655 H		8660 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1/16	46	39	48	40	50	42	51	43	53	45	54	46	56	48	57	49	59	51	60	52	62	54	63	55	64	56	65	58	65	59	—	60	—	60
1/8	44	33	47	37	49	39	50	41	52	43	54	45	55	46	57	49	58	51	60	52	62	54	63	55	64	56	65	58	65	59	—	59	—	60
3/16	41	27	44	32	47	34	48	36	50	38	53	42	54	44	56	47	58	50	60	52	62	53	62	55	64	56	65	57	65	59	—	59	—	60
1/4	38	24	41	27	44	30	46	32	48	35	52	39	53	42	55	45	57	48	59	51	61	52	63	54	64	55	64	57	65	58	—	58	—	60
5/16	34	20	37	23	40	26	43	29	45	32	51	38	54	42	56	45	59	49	61	50	62	52	63	54	64	56	65	58	65	58	—	57	—	60
3/8	31	—	34	21	37	24	40	27	43	29	47	32	49	35	53	39	55	42	58	46	61	50	62	52	63	54	64	57	65	58	—	56	—	59
7/16	28	—	32	—	34	22	37	25	40	27	44	29	46	32	51	35	54	39	57	42	59	45	61	48	62	50	63	53	64	57	—	55	—	58
1/2	27	—	30	—	32	20	35	23	38	26	41	28	43	30	50	33	53	36	55	39	58	42	60	45	61	47	62	50	64	56	—	54	—	57
9/16	26	—	29	—	31	—	33	22	36	24	39	27	41	28	48	31	51	34	54	36	57	39	59	41	60	44	61	47	63	55	—	52	—	55
5/8	25	—	28	—	30	—	32	21	34	24	37	26	39	27	46	30	49	32	52	34	55	37	58	39	59	41	60	44	63	53	65	49	—	53
11/16	24	—	27	—	29	—	31	20	33	23	35	25	37	26	45	29	47	31	50	32	54	34	56	37	58	39	60	41	63	49	65	46	—	50
3/4	23	—	26	—	28	—	30	—	32	22	34	24	36	25	43	28	46	30	49	31	52	33	55	35	57	37	59	39	62	47	64	43	—	47
13/16	23	—	25	—	27	—	29	—	31	21	33	23	35	24	41	27	44	29	47	30	50	32	54	34	56	35	58	37	62	45	64	41	—	45
7/8	22	—	25	—	26	—	28	—	30	21	33	22	35	24	40	26	43	28	45	29	49	31	52	33	55	34	58	36	62	44	63	40	—	44
15/16	22	—	24	—	26	—	28	—	30	20	32	22	34	23	38	25	41	27	44	28	48	30	51	32	54	33	57	35	62	43	63	39	—	43
1	21	—	24	—	25	—	27	—	29	20	31	21	33	23	37	25	40	26	42	28	46	29	49	31	53	33	56	34	61	42	62	38	65	42
1-1/8	21	—	23	—	25	—	27	—	28	—	30	21	32	22	36	24	39	25	41	26	44	28	47	30	51	32	55	33	61	40	61	37	64	40
1-1/4	20	—	23	—	24	—	26	—	28	—	30	20	32	21	35	23	37	25	39	26	42	28	45	29	49	31	53	32	60	39	64	39	64	39
1-3/8	—	—	23	—	24	—	26	—	28	—	29	20	31	21	34	23	36	24	38	25	41	27	43	28	48	30	52	31	59	38	59	34	63	38
1-1/2	—	—	23	—	24	—	26	—	27	—	29	—	31	21	33	23	36	24	38	25	40	27	42	28	46	30	50	31	59	37	58	34	62	37
1-5/8	—	—	23	—	24	—	26	—	27	—	29	—	31	20	33	23	35	24	37	24	40	26	42	27	45	29	49	30	59	36	57	33	62	36
1-3/4	—	—	22	—	24	—	25	—	27	—	29	—	31	20	32	22	35	24	37	24	39	26	41	27	44	28	47	30	59	35	56	33	61	36
1-7/8	—	—	22	—	24	—	25	—	27	—	29	—	31	—	32	22	35	23	37	24	39	26	41	27	43	28	46	29	58	35	53	32	60	35
2	—	—	22	—	24	—	25	—	27	—	29	—	31	—	32	22	35	23	37	24	39	26	41	27	43	28	45	28	58	34	53	32	60	35

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 21
END-QUENCH HARDENABILITY BANDS
Tabulation of Band Limits — 8700 H*

	GRADE											
	8720 H		8735 H		8740 H		8742 H		8745 H		8747 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	48	40	57	49	60	52	62	54	63	55	64	56
1/8	47	38	57	49	60	52	62	54	63	55	64	56
3/16	45	35	57	49	60	52	62	54	63	55	64	56
1/4	42	30	56	48	60	51	61	53	62	54	63	55
5/16	38	26	55	45	59	49	61	52	62	53	63	55
3/8	35	24	54	41	58	46	60	49	61	52	62	54
7/16	33	22	53	37	57	43	59	47	61	49	62	52
1/2	31	21	51	35	56	40	58	44	60	47	61	50
9/16	30	20	49	33	55	37	57	41	59	45	60	48
5/8	29	—	48	31	53	35	56	39	58	43	59	46
11/16	28	—	46	30	52	34	54	37	57	40	59	44
3/4	27	—	45	29	50	32	53	35	56	39	58	42
13/16	26	—	44	28	49	31	52	34	55	37	57	40
7/8	26	—	42	27	48	31	51	33	54	36	57	39
15/16	25	—	41	26	46	30	49	32	53	35	56	37
1	25	—	39	26	45	29	48	31	52	34	55	36
1-1/8	24	—	38	25	43	28	46	30	50	33	53	34
1-1/4	24	—	36	25	42	28	45	29	48	32	52	33
1-3/8	23	—	36	24	41	27	43	29	46	31	50	32
1-1/2	23	—	35	24	40	27	42	28	45	30	49	32
1-5/8	23	—	35	24	39	27	42	28	44	30	47	31
1-3/4	23	—	35	23	39	27	41	28	44	29	46	31
1-7/8	22	—	35	23	38	26	41	28	43	29	46	31
2	22	—	35	23	38	26	40	27	42	29	45	30

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 22
END-QUENCH HARDENABILITY BANDS
Tabulation of Band Limits — 9200 H*

"J" Distance Inches	GRADE					
	9260 H		9261 H		9262 H	
	Max.	Min.	Max.	Min.	Max.	Min.
1/16	—	60	—	60	—	60
1/8	—	60	—	60	—	60
3/16	65	57	—	60	—	60
1/4	64	53	65	59	—	60
5/16	63	46	65	56	—	58
3/8	62	41	64	52	65	56
7/16	60	38	64	47	65	53
1/2	58	36	63	42	64	48
9/16	55	36	62	39	63	42
5/8	52	35	60	37	62	39
11/16	49	34	57	36	61	37
3/4	47	34	54	36	59	37
13/16	45	33	49	35	57	36
7/8	43	33	45	35	55	36
15/16	42	32	43	34	51	35
1	40	32	42	34	48	35
1-1/8	38	31	39	33	45	34
1-1/4	37	31	38	32	43	33
1-3/8	36	30	37	31	41	33
1-1/2	36	30	37	31	39	32
1-5/8	35	29	36	30	38	31
1-3/4	35	29	36	30	37	31
1-7/8	35	28	35	29	36	30
2	34	28	35	29	36	30

*These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 23

END-QUENCH HARDENABILITY BANDS

Tabulation of Band Limits* — 9300 H

"J" Distance Inches	GRADE	
	9310 H	
	Max.	Min.
1/16	43	35
1/8	43	35
3/16	43	35
1/4	42	34
5/16	42	32
3/8	42	31
7/16	42	30
1/2	41	29
9/16	40	28
5/8	40	27
11/16	39	27
3/4	38	26
13/16	37	26
7/8	36	26
15/16	36	26
1	35	26
1-1/8	35	26
1-1/4	35	25
1-3/8	34	25
1-1/2	34	25
1-5/8	34	25
1-3/4	34	25
1-7/8	33	24
2	33	24

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

Table 24

END-QUENCH HARDENABILITY BANDS

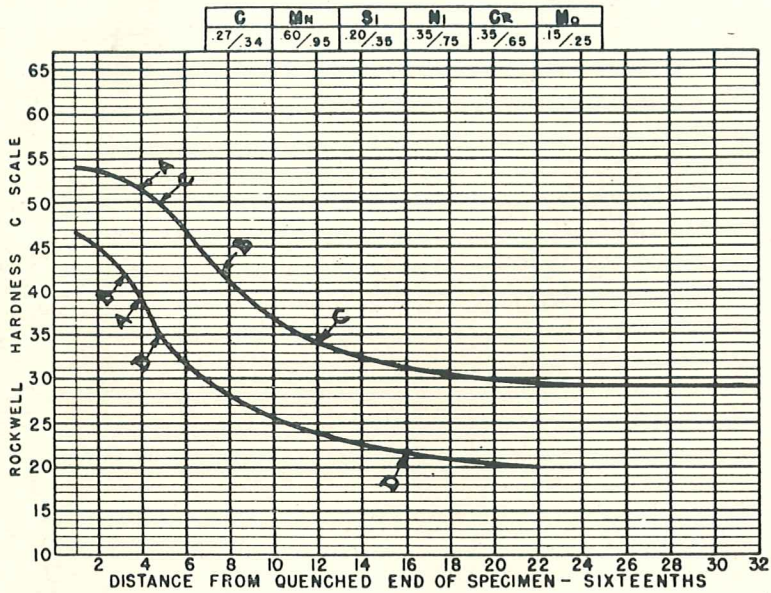
Tabulation of Band Limits* — 9400 H

"J" Distance Inches	GRADE							
	9437 H		9440 H		9442 H		9445 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	59	51	60	52	62	54	63	55
1/8	58	49	60	51	62	52	63	54
3/16	58	47	60	49	62	51	63	53
1/4	57	43	59	46	61	48	63	51
5/16	57	40	59	43	61	45	62	49
3/8	56	37	58	40	60	43	62	46
7/16	55	35	57	37	59	40	62	43
1/2	53	33	55	35	59	38	61	41
9/16	51	31	54	33	58	36	60	39
5/8	50	30	52	32	57	34	59	37
11/16	48	28	51	30	55	32	58	35
3/4	47	27	50	29	54	31	57	34
13/16	46	26	49	28	53	30	56	33
7/8	45	26	48	27	52	29	55	32
15/16	44	25	47	26	51	28	54	31
1	43	24	46	25	50	27	53	30
1-1/8	42	23	45	24	48	26	52	29
1-1/4	41	22	43	23	47	25	50	28
1-3/8	40	21	42	22	46	25	49	27
1-1/2	39	21	41	22	45	24	48	26
1-5/8	39	21	41	22	44	24	47	26
1-3/4	38	20	40	21	43	24	46	26
1-7/8	38	20	40	21	43	24	46	26
2	38	20	39	21	43	23	45	26

* These values were adjusted to the nearest Rockwell "C" point, and are used when points are selected and specified.

EXAMPLES ILLUSTRATING ALTERNATE METHODS
OF SPECIFYING REQUIREMENTS (TABULATED
HARDNESS VALUES ARE USED IN ORDERING).

HARDENABILITY BAND 0630 H



METHOD	EXAMPLE
A—Minimum and Maximum Hardness Values at a Desired Distance.	A-A J39/52 = 4/16 in.
B—A Desired Hardness Value at Minimum and Maximum Distances.	B-B J42 = 3/16 in. to 8/16 in. (Minimum Distance to Nearest 1/16 in. at Left and Maximum to Nearest 1/16 in. at Right).
C—Two Maximum Hardness Values at Two Desired Distances.	C-C J50 = 5/16 in. Max. J34 = 12/16 in. Max.
D—Two Minimum Hardness Values at Two Desired Distances.	D-D J35 = 5/16 in. Min. J21 = 16/16 in. Min.

Part VI

**PACKAGING, MARKING AND
LOADING METHODS**

Part VI

PACKAGING, MARKING AND LOADING METHODS

Introduction

Cold finished steel bars are among the most highly finished products of the steel industry. Because of their high finish and the exacting uses to which such products are put, packaging and loading methods are very important.

The problem of package selection has many ramifications. First and most important, producers endeavor to package their product to assure arrival at destination in as nearly perfect condition as possible, and as economically as possible. It is evident that the interests of purchaser and producer toward the achievement of the above objectives are identical.

If upon delivery there is any evidence of loss or damage, it has been found advisable that the carrier's representative be called in for inspection before unloading and proper notation made on the freight bill.

After the product has been delivered, purchasers are faced with the problem of disposal of the packaging and bracing materials. For that reason the simplest package is the most desirable; and in this respect purchaser and producer interests are again identical.

The methods illustrated in this part reflect the results of years of experience by steel producers in satisfactorily delivering their products by various methods of transportation. In the interests of satisfactory delivery, purchasers have found it desirable to consult with the producer as to the proper method to use for special unloading, specific destinations, or different methods of transportation.

It is to be expected that some of the methods shown will be improved upon as a result of research work which is in continuous progress. As the occasion arises, a revision of this part will be prepared.

GENERAL PROVISIONS

Cold finished bars and bar size shapes are customarily shipped loose in closed cars or in large lifts in open top cars.

Due to the high finish of these products, it is recommended that they be shipped in closed cars for the maximum protection in transit.

Loading Closed Cars

The shipper is governed generally by the latest edition, or supplements thereto, of the "Recommended Methods for Loading Carload Shipments in Closed Cars" as published by the Association of American Railroads. Except as modified by these recommendations, the method of loading and bracing to be followed is governed by the facilities available at the mill.

Every effort is made to use only clean cars having tight roofs and solid floors.

Loading Open Top Cars

In all cases the shipper is governed by the latest edition, or supplements thereto, of the "Rules Governing the Loading of Commodities on Open Top Cars" as published by the Association of American Railroads.

Every effort is made to use only clean cars having wooden sides and ends and solid wood floors.

Separation of Units in Cars

When the separation of lifts or piles in cars is required by reason of clearances needed for purchaser's unloading equipment, separators or bearing pieces are furnished up to a maximum of commercial four-inch lumber. Larger size separators or bearing pieces are not commonly required.

Identification

Color Marking. When the marking of bars with identification colors is required, the following practices are employed:

Sizes $1\frac{1}{2}$ inches and over are marked on one end, and with not more than two colors.

Sizes smaller than $1\frac{1}{2}$ inches are not marked individually but the bundle, lift or pile is marked on one end with a dab of paint of one color, or not more than two different colored stripes.

When the back of the tag is marked, one or two colors are used, or the names of colors are spelled out.

Any paint marking other than noted above slows the normal marking procedure.

Superimposed color marking requires additional time for drying.

Die Stamping. This method of marking retards the normal flow of materials.

Tagging. Bundles, lifts or piles are generally identified with not more than one tag each.

When definite information is required to be shown on tags, it commonly consists of:

- Purchaser's order number
- Grade or specification
- Size and length
- Heat number

Counting and Weighing

Cold finished bars and bar size shapes are invoiced on mill scale weights. In check weighing by the purchaser, variation from invoiced weights up to one per cent is normal expectancy, due to differences in kind, type, location and accuracy of scales.

When the number of pieces in the bundle or lift is required to be shown on the tags and shipping papers, the count is commonly considered as approximate and weight the more accurate.

Packing Lists or Tally Sheets

Packing lists are furnished upon request of the purchaser. Such lists are compiled as accurately as practicable, but they are subject to conformation to the official shipping notice or invoice.

PACKAGING AND LOADING PRACTICES

Loose Bars

When loaded in closed cars, cold finished bars and bar-size shapes, with the exception of rounds, squares, hexagons or similar sections, 5/16 inch and under, are not commonly bundled or put up in lifts, but are loaded loose, and the various sizes and grades are separated by wire, bands, wood or other suitable methods. Extraordinary methods of separation or loading tend to retard normal operations.

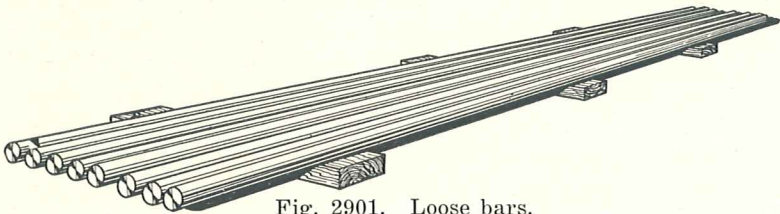


Fig. 2901. Loose bars.

The term loose means single pieces that can be handled individually. This method of loading is commonly used by producers in the loading in closed cars of all sizes of bars over 5/16 inch.

Hand Bundles

Cold finished round, square, hexagon or similar bar sections 5/16 inch and under are put up in hand bundles because of the flexible nature of the material.

Fig. 2902 illustrates a typical hand bundle. Such bundles are hand tied with No. 14 gage wire, or its equivalent, and

contain approximately 150 to 200 pounds. When so bundled, not less than 3 pieces are made into a bundle. Tying practice is as follows:

Up to 8 ft.	Over 8 ft. to 16 ft.	Over 16 ft. to 20 ft.	Over 20 ft. to 24 ft.
2 Ties	3 Ties	4 Ties	5 Ties

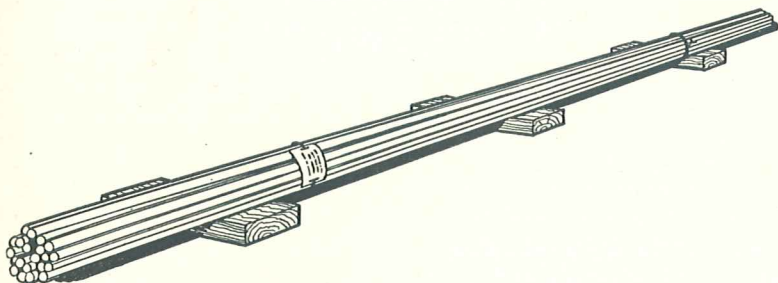


Fig. 2902. Hand bundle.

Bundling of sizes over $5/16$ inch requires additional handling.

Conventional Lift

The minimum quantity of bars in a conventional lift is 6000 pounds. Producers generally desire that purchasers specify the maximum possible weight unit because heavier units withstand transportation hazards better and result in greater economy to both the purchaser and producer. This type of package is used only for open top cars or truck shipments.

The packaging of bars into lifts for closed car loading requires additional handling.

Fig. 2903 illustrates a conventional lift. The securement of this type of package consists of a maximum of three hand ties of approximately No. 5 gage soft wire rod, double wrapped, or other material of equivalent strength.

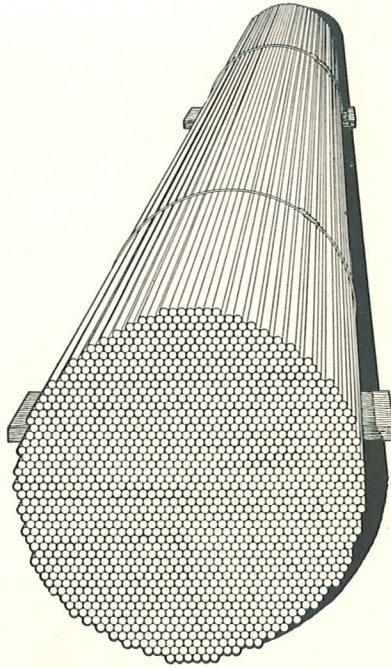


Fig. 2903. Conventional lift.

CONTAINERS

As stated above, it is common practice to ship cold finished bars loose or in hand bundles or lifts. However, due to the special high finish and very close tolerances of some cold finished bars and bar size shapes, they require packaging in special containers for extra protection against damage. This type of packaging requires additional material and handling.

Chip Board Tube

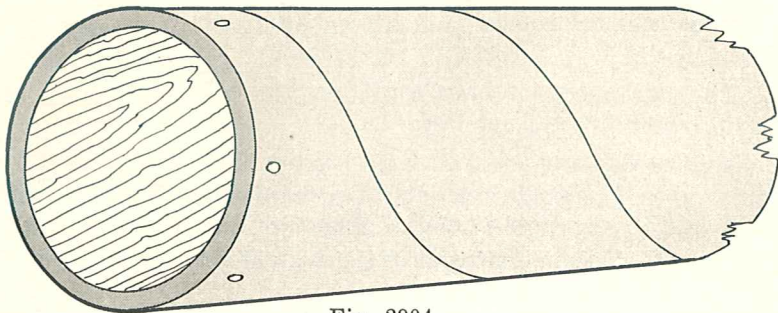


Fig. 2904.

Fig. 2904 illustrates a typical chip board fiber container. Such containers, when required, are made from heavy spirally wound chip board with 2 inch ends and reinforced with sheet metal collars at each end.

Metal Container

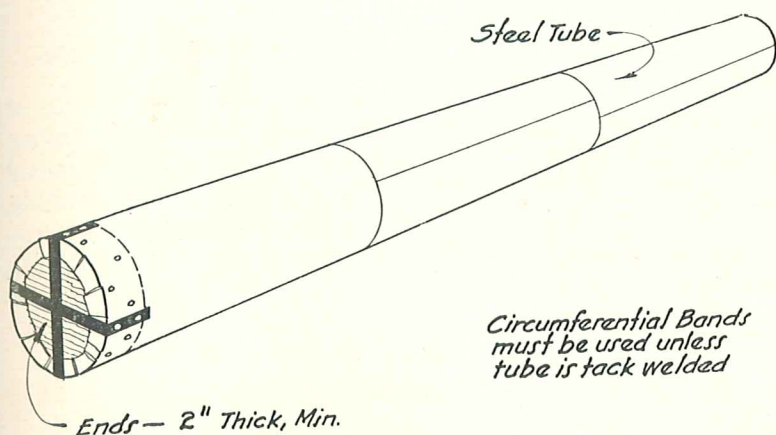


Fig. 2905. Special metal container.

Fig. 2905 illustrates a typical metal container. Such containers, when required, are made from light gage sheets of approximately 30 gage and have wooden ends approximately 2 inches thick.

Wood Box

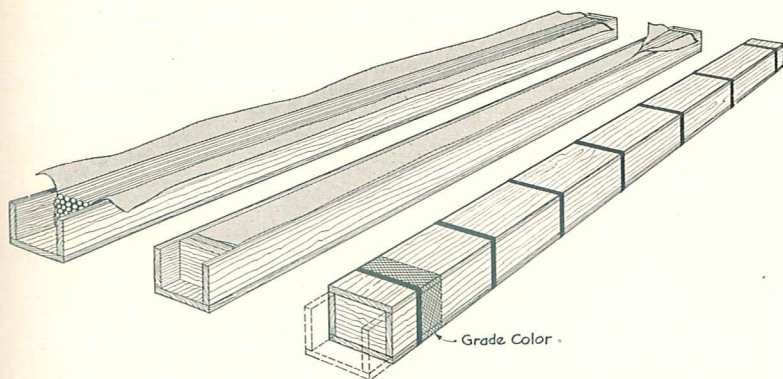


Fig. 2906. Typical wood box.

Fig. 2906 illustrates a typical wood box as sometimes required. Such boxes are commonly made from $\frac{3}{4}$ inch seasoned lumber, lined with paper, and are reinforced with bands or wire at ends and at intermediate points, depending upon the length of the box.

Less Than Carload or Less Than Truck Load Shipments

Less than carload or less than truck load shipments of turned and polished, turned ground and polished, cold drawn ground and polished bars and shafting or any bars produced to high finish are packaged in either chip board tubes, boxes or metal containers, due to the rehandling at transfer stations. This requires additional packaging material and handling.

Wrapping, Shrouding or Covering Open Top Car Shipments

Shipments of cold finished bars in open top cars have either the large lifts wrapped or shrouded, or the entire load covered or shrouded, but not both. Requirements for covering open top cars with tarpaulin roofs, or wrapping and shrouding each lift, involve additional handling and material.

Wrapped Lift

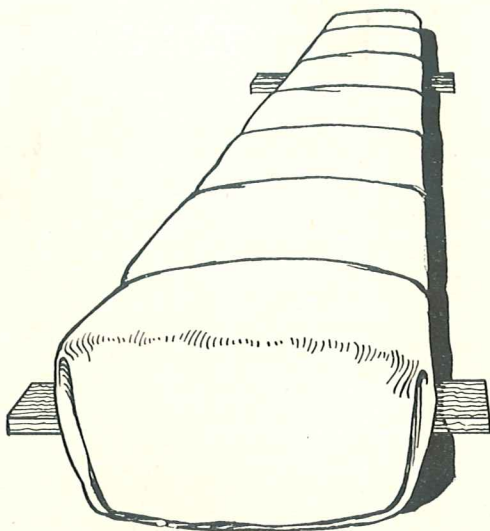


Fig. 2907. Wrapped lift.

Fig. 2907 illustrates a typical method of completely wrapping lifts for shipping in open top cars. The material used is waterproof paper folded loosely around the steel. The overlap and all end folds are made with the laps down. No tar or other sealing compound is used. The paper wrapping is secured to the lift with light gage soft wire or other suitable material.

Shrouding Open Top Car Shipments

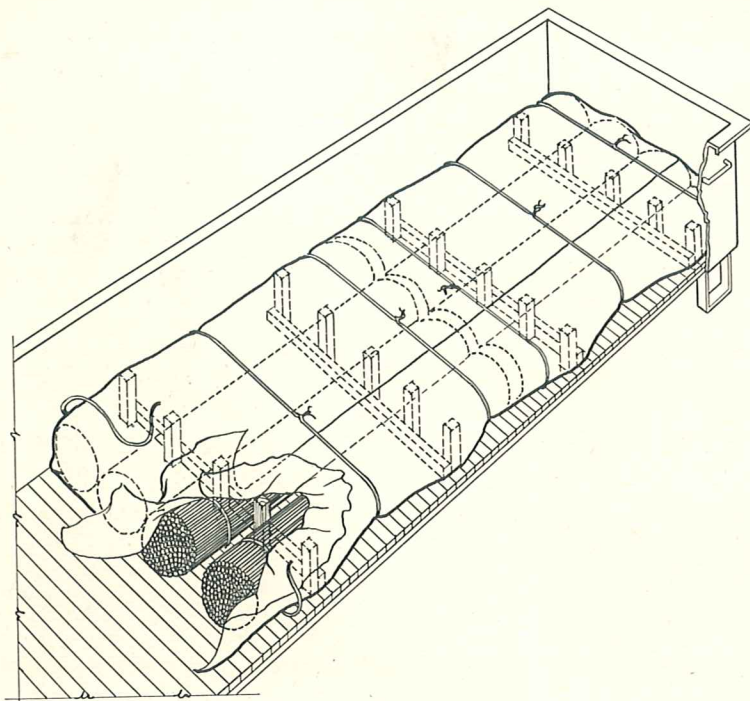


Fig. 2908. Shrouded carload.

Fig. 2908 illustrates a typical method of shrouding the carload. The material used is waterproof, folded over a number of lifts or the entire carload and secured with light gage soft wire or other suitable material. If the shroud is of such size as to necessitate using more than one piece, experience has shown that the joints should have an overlap of at least one foot.

Covering Open Top Car Shipments

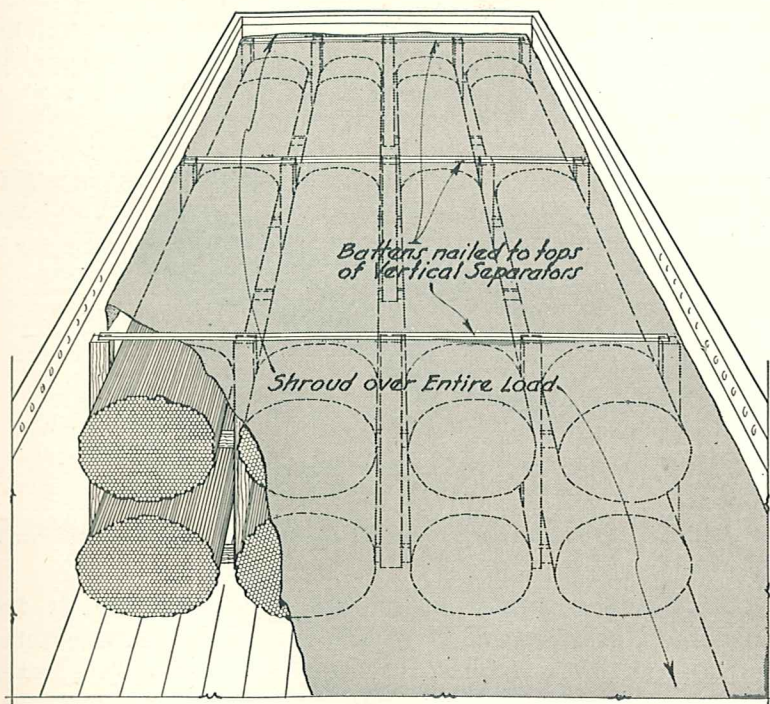


Fig. 2909. Covered carload.

Fig. 2909 illustrates a typical method of covering the carload. The material used is waterproof and secured to the carload by the use of light wooden skeleton framework or other suitable material. If it is necessary to use more than one piece of covering material, experience has shown that the joints should have an overlap of at least one foot.

STACK PILING

This method of piling is commonly applied to straightened flats and consists of arranging single pieces in order, one above the other, into conventional lifts of 6,000 pounds minimum weight, made up of one or more piles.

When stack piling is specified for other than straightened flats, additional handling is generally required.

The stacking or piling of all bars or bar size shapes, including straightened flats, into lifts of specified count or dimensions involves additional handling.

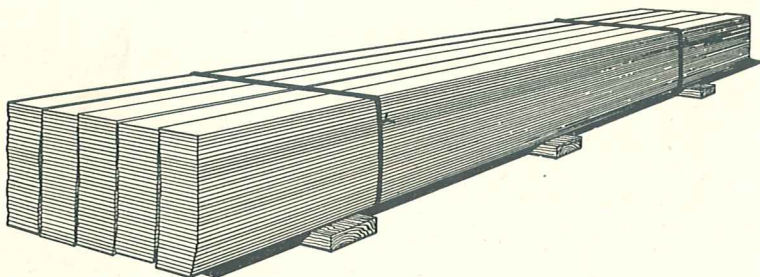


Fig. 2910. Stack pile of straightened flats.

Fig. 2910 illustrates a typical method of stack piling and tying.

Producers generally desire that purchasers specify the maximum possible weight unit because heavier units withstand transportation hazards better and result in greater economy to both the purchaser and producer.

This type of package is used only for open top car shipments.

Stack piling of bundles or lifts for closed car loading requires additional handling.

TYPICAL CAR LOADING METHODS

Loading Closed Cars

Figs. 2911, 2912 and 2913 illustrate typical methods of loading and bracing cold finished bars and bar size shapes in closed cars.

Soft wood dunnage strips of 1-inch maximum thickness are placed on the floor of the car to protect the material in transit from damage, due to rough and uneven floors.

Headers and bracing are made from commercial 2-inch hardwood lumber; the headers are slightly higher than the lading and suitably braced to prevent shifting in transit.

Headers are tied down with either hold-down boards nailed to the side or door posts of the car, or any other suitable method.

Wrapping or shrouding of cold finished bars loaded in closed cars involves additional material and handling.

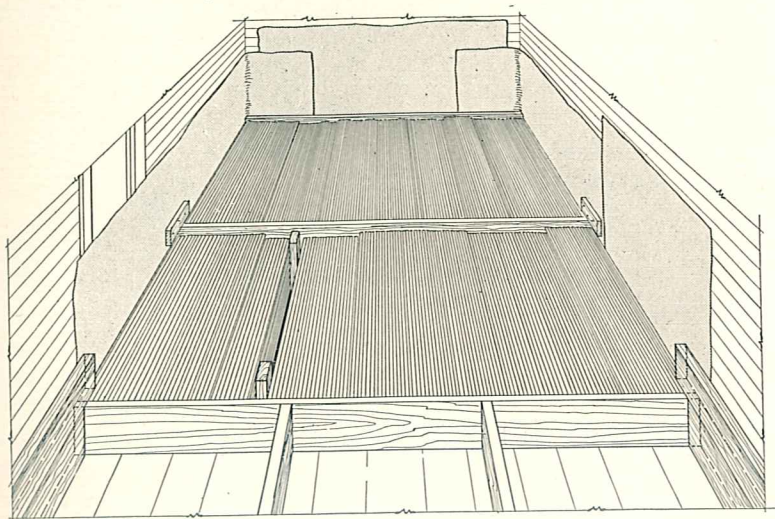


Fig. 2911.

Fig. 2911 illustrates a typical method of loading, bracing and applying hold-down boards in closed cars.

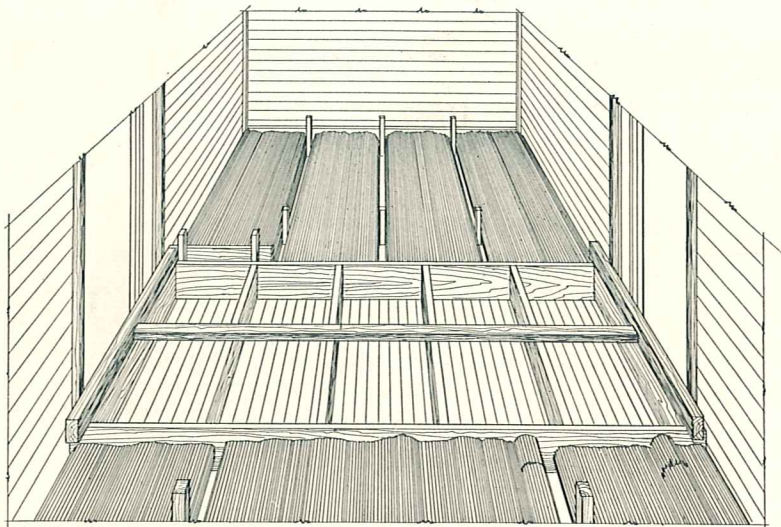


Fig. 2912.

Fig. 2912 illustrates a typical method of loading, bracing and applying hold-down boards in closed cars.

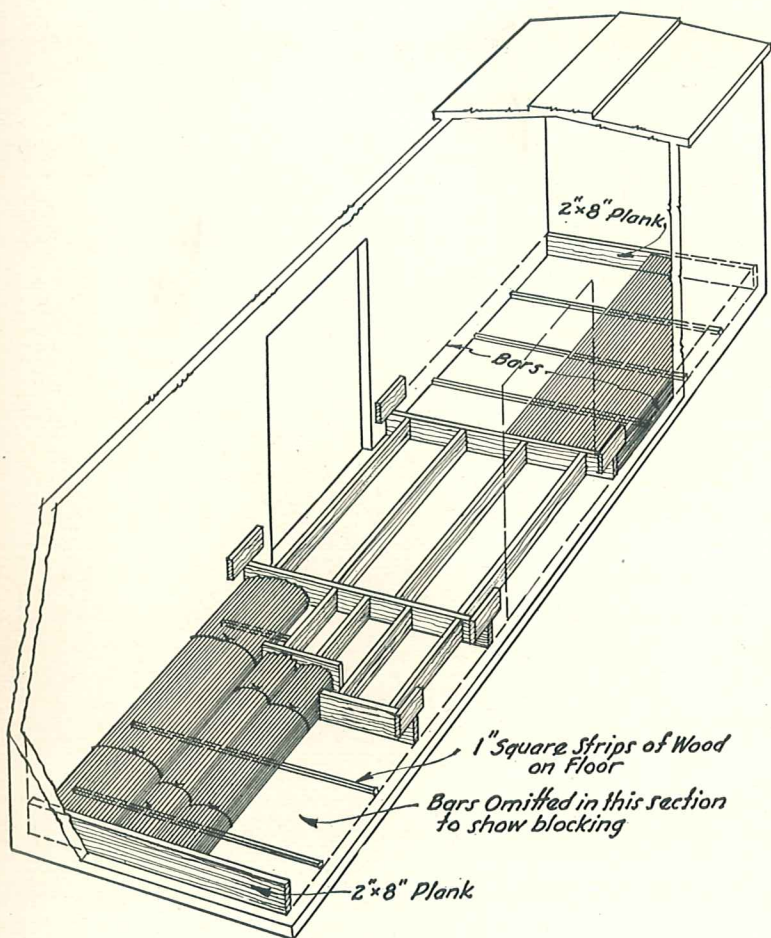


Fig. 2913.

Fig. 2913 illustrates a typical method of loading, bracing, and applying hold-down boards and wire separators in closed cars.

Loading Open Top Cars

Figs. 2914 and 2915 illustrate typical methods of loading and bracing cold finished bars and bar size shapes in open top cars.

The A.A.R. standard maximum clearance, either vertical or horizontal, for separation of lifts or bearing pieces is maintained by the use of commercial 4-inch hardwood blocking.

Headers and bracing are made from commercial 2-inch hardwood lumber.

The headers are slightly higher than the lading and suitably braced to prevent shifting in transit. Headers are tied down with hold-down blocks nailed to the sides of the car or by other suitable methods.

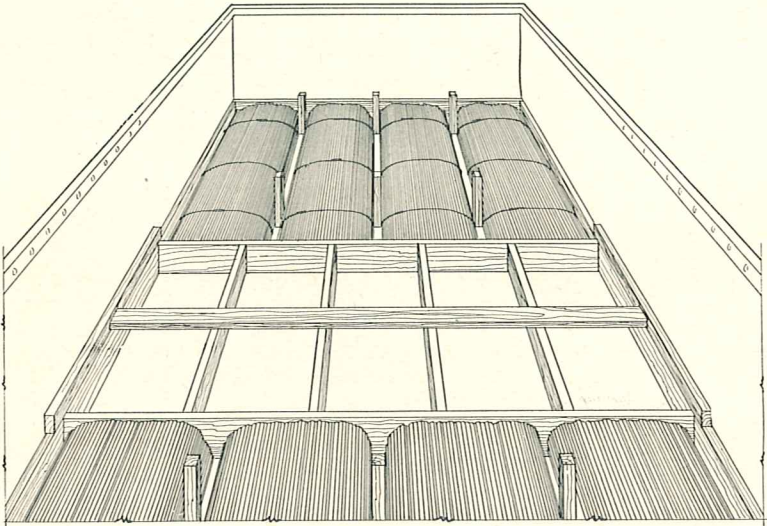


Fig. 2914.

Fig. 2914 illustrates a typical method of loading, bracing and applying hold-down boards in open top cars.

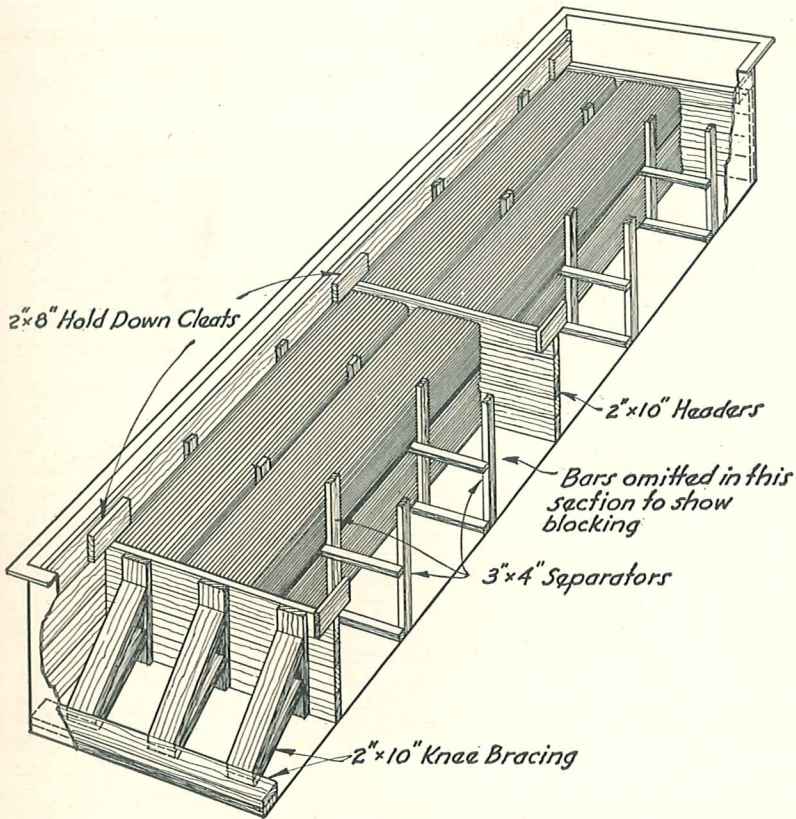


Fig. 2915.

Fig. 2915 illustrates a typical method of loading, bracing and applying hold-down boards in open top cars.

GLOSSARY

PACKAGING AND LOADING TERMS

Binder. Any material used for securement of packages.

Blocking, Bracing or Dunnage. Material loose or attached to car, such as metal, wood blocking, stakes, timber, bulkheads, bolsters, bracing, bearing pieces, skids, standards, strips, sliding pieces, metal ties, or other bracing used to protect or support shipments in, or on, cars.

Brand. Customer's or producer's trade-mark.

Bundle. A unit of specified weight or count, secured, that can be handled by hand.

Covered. Top, sides and ends of package covered with water-repellent paper and fastened.

Cross Pieces. Supports placed across the width of the unit or units shipped, for protection of shipment in transit.

Fillers. One or more wooden pieces placed between different lengths for the purpose of squaring out piles for proper application of bracing.

Length Pieces. Supports placed lengthwise of unit or units shipped, for protection of shipment in transit.

Lift. A unit of specified weight, count or dimensions, that can be handled individually by mechanical equipment.

Loose. Single pieces that can be handled individually.

Mark. Information applied freehand with chalk or a brush.

Marker. Any material inserted for the purpose of maintaining identification of gage, size, quantity, grade or heat numbers.

Metal Cushion. Metal strip placed under tension bands to prevent bands from injuring steel.

Metal Package. A package wrapped with water-repellent paper, entirely covered with steel for protection.

Package. A lift, or a number of lifts or hand bundles, secured in at least one direction into a single unit.

Package Stiffener. A wood piece of any required dimensions placed under a bundle or piece lengthwise to prevent very flexible material from bending when shipped less carload, less truckload, or express.

Plywood Box. A container made of plywood entirely enclosed, lined or unlined as specified.

Separator. Any material used for dividing and maintaining necessary clearance for protection of shipment in transit.

Separator Protection. Material used to prevent damage to bars by skids or separators.

Shroud. Loose waterproof covering, attached over the finished unit after tying has been completed.

Stencil. Information applied with a rubber stamp or brushed on by use of stencil.

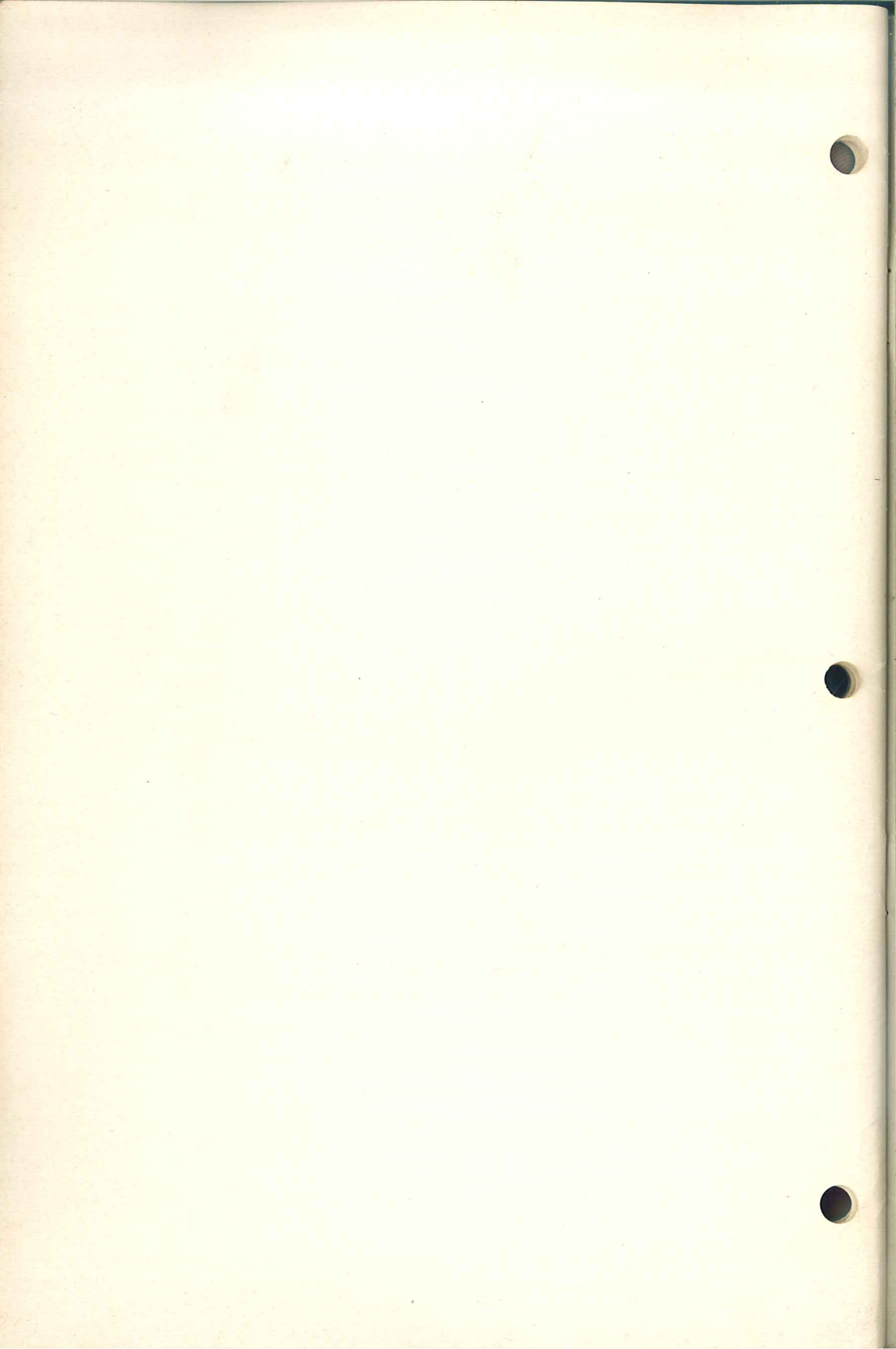
Tag. Fiber or carboard used for describing contents or supplying shipping information, attached to the unit. Metal tags are used only if specified.

Tally or Packing List. Itemized report of all material in shipment.

Tension Tied. Securement applied with mechanical tools.

Wood Box. A container made of wood entirely enclosed, lined or unlined as specified.

Wrapped. Unit entirely wrapped with waterproof paper, with all folds down.



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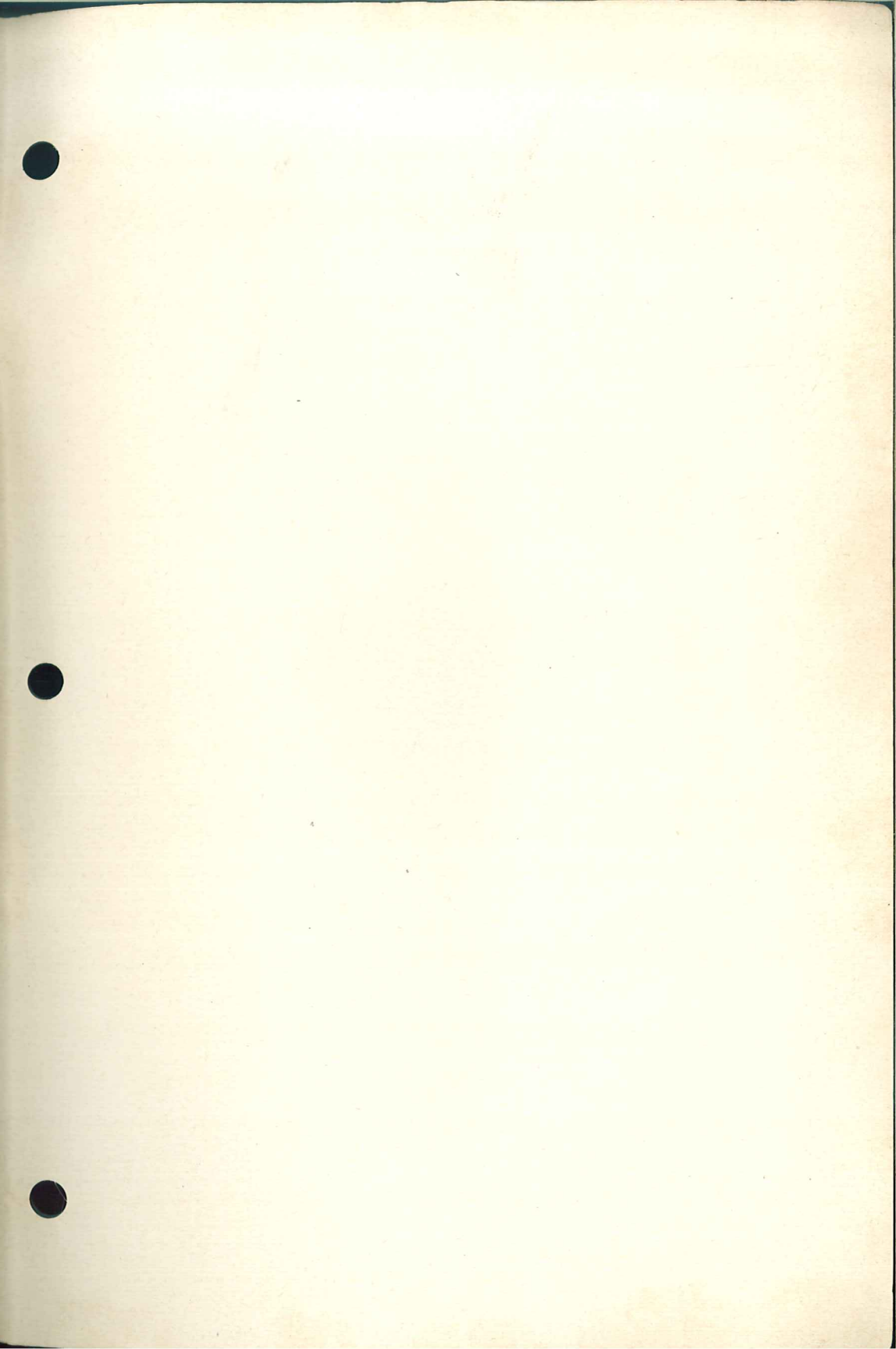
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